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LECTURE NOTES ON PHYSIOLOGY

BY

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HYGIENE

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HYGIENE

The science of hygiene is very closely related to the science of bacteriology.

Subdivisions of Hygiene and Its Definition—The subject of hygiene may be divided into two very unequal and two very distinctly separated portions. First, those hygienic precautions, which the individual should exercise in order to preserve his health quite apart from relations with other individuals. Second, those hygienic precautions, serving to protect the individual from those dangers to his health which depend upon his relations with other individuals.

The first subdivision may be entitled personal hygiene and from it must be excluded all diseases of bacterial or parasitic origin, because all such diseases depend upon some primary source of infection in some other individual. It deals solely with the prevention of ill health, which comes from depression of the general vitality, or from ill health due entirely to metabolic disturbances. Such causes of ill health relate almost entirely to dietary errors, improper protection from injury by trauma, cold, heat, water, or improper relations between work, rest, and recreation. All these matters are, with few exceptions, directly under the control of the individual and are, therefore, purely personal matters. Even some of these matters, however, concern social relations; particularly, when groups of individuals become subjected to improper personal hygienic conditions by other individuals on whom they are dependent for education or employment.

Again many matters, which concern strictly personal hygiene, become of importance chiefly because they make the individual an easier prey to bacterial infections. Comparatively few matters falling under the classification of personal hygiene have no relation to bacterial infection. In fact, those matters of personal hygiene having no relation to bacterial infections occupy a very small space at the present time in discussions on hygiene.

For these reasons, hygiene may be fairly accurately defined

as that science which aims to establish healthful relations for individuals with each other. These relations concern chiefly the mutual relations between individuals or relations which virtually concern, solely, the prevention of the spread of pathogenic bacteria from one individual to another. For this reason General Hygiene is most intimately related to Bacteriology.

General Hygiene concerns the source, the kind, the quality, and the preservation of the food which we eat, the quality of the air which we breathe, and the water which we drink, and the water in which we bathe. By deviations from a standard in any of these particulars not only may the food, air or water become a direct means of transfer of bacteria from one individual to another; but also the individual may become so weakened that he may become an easier prey to accidentally transferred bacteria, which under other conditions of health he would be able to resist.

Under the conditions mentioned, he becomes a source of danger to others. A part of the protection, therefore, which all individuals have the right to expect from the State is the protection from sources of danger arising from the poor state of health in other individuals. The State has the right to step in and alter any condition facilitating the transfer of bacteria from one individual to another, or any condition rendering any individual more liable to receive and, therefore, to spread the pathogenic bacteria.

The science of hygiene investigates all conditions permitting the transfer of pathogenic bacteria with a view of preventing the actual transfer. As a result regulations have been formulated and laws passed which have already led to a greatly decreased death-rate in all the large cities.

FOOD

Divisions of Foodstuffs Which We Eat—Foodstuffs may be divided into proteins, carbohydrates, and fats. For the normal individual that diet which most spares the activities of the various internal organs and still supplies sufficient energy and nutritional units is the most economical.

Amounts of the Three Foodstuffs Constituting an Economical Diet—The body at all times needs a definite proportion of pro-

teins, carbohydrates, and fats. This proportion varies little during periods of extreme exertion and periods of rest. In health, a largely protein or strictly vegetarian diet is not the most economical. In regard to amounts, the average individual should eat food having a caloric value of 3,333 per diem.

For the average working individual this should be divided as follows:

Protein	120 grams to 130 grams
Fats	55 grams to 100 grams
Carbohydrates	500 grams

As the heat value of 1 gram of protein is approximately 4.1 calories,

and of 1 gram of fat 9.3 calories,
and of 1 gram of carbohydrates 4.1 calories,

this diet would furnish the individual with 3,053 to 3,513 calories a day.

For women	Proteins	94 grams
	Fat	45 grams
	Carbohydrates	400 grams are suggested.

These quantities have a caloric value of 2,444.

Relative Proportions of the Three Foodstuffs in the Various Commercial Foods—It is important to know something of the relative proportions of the three foodstuffs in the various foods which we eat and their approximate caloric value. What would otherwise be a laborious calculation has been made very easy by the tables which the United States Department of Agriculture has published.

Proportion of the Foodstuffs and Caloric Value of the Meats—Of the meats including beef, liver, tongue, roast beef, steak, ham, pork, veal, mutton, lamb, and poultry,

The proteins vary from 15.3 to 23.9 per cent,
The fats vary from 2.5 to 30 per cent,

according to the amount of obvious fat present. Lean poultry has the least and fat pork the most. Steak, mutton, and beef have values of 10, 18, and 28 per cent. The caloric value varies chiefly with the quantity of fat present. A high content of fat greatly

runs up the caloric value of the meat. In lean poultry and steak, for instance, in which the fat is small in amount, the caloric value is 505 to 875. In pork and beef it is 1,580 to 1,620 calories. In fish the proteins vary from 14 to 22 per cent. The average is about 18 per cent. The fat in salmon is between 3 and 17.8 per cent. The average is about 5 per cent. The caloric value runs from 335 to 1,080 according to the amount of fat present.

Relative Digestibility and Preparation of the Meats—Beef and the white meat of poultry is probably the most digestible of the meats; mutton is a close second; veal varies greatly with the individual; pork is the hardest to digest. As a rule the digestibility is rendered difficult by a large content of fat.

Raw meat is more easily digested than cooked meat, though cooked meat is more completely digested.

Broths are infusions of meat. They usually consist chiefly of salts in solution but their protein contents may be increased by the addition of lactic acid to the water with which the infusion is made. Boiled meat or stewed meat usually lacks many of the salts which improve the flavor of the meat. It consists of coagulated meat. The coagulation point of the protein of meat is 134° F. If the temperature is raised to 160°, gelatin is formed from the collagen of the connective tissue. Meat becomes far tougher if the stewing is conducted at a higher point than 180°.

Meat may be fried. The fat which is used for frying should be very hot so that the surface of the meat may be quickly coagulated. This permits the retention of all the juices and prevents the fat penetrating very far into the meat.

Characters of Good Meat—Good meat should have a uniform color or should be firm and elastic and give out no objectionable odor.

Digestibility and Preparation of Fish—Fish in general is more indigestible than meat. Fish is very liable to decompose rapidly. The rapidity with which it decomposes is increased by allowing it to die slowly. Fish, therefore, should be quickly killed after catching and eaten when very fresh.

Fish is preserved by smoking and salting. Both of these methods increase its indigestibility and greatly reduce the pleasantness of its flavor. Mollusks, oysters, and clams are the most digestible of fish. Oysters contain 1 to 2 per cent of fat and 6 to 8

per cent of proteins. Lobsters and crabs are the most indigestible forms of fish. The fishes rich in fat, as trout and salmon, are relatively to other fish more indigestible.

The Parasites of Meat and Fish—Meat and fish are a source of danger chiefly from the parasites and bacteria which they contain.

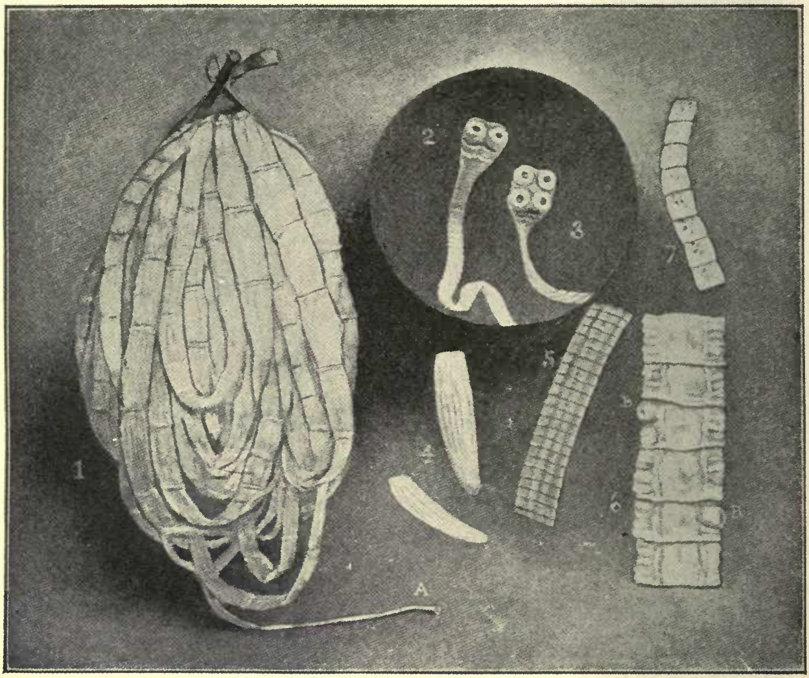


Fig. 1. Cestodes (tapeworms). 1, Taenia saginata. A, Head of taenia saginata. 2, Dorsal view of the head. 3, Apex view of head, showing depression in center. 4, Isolated, elongated segments. 5, Bothriocephalus latus. 6, Ripe segments of taenia saginata. B, showing location of sexual organs. 7, Half-developed segments of taenia saginata. Illustrations drawn from specimens. (Fischer.)

Tapeworms—Two forms of tapeworm commonly infecting man may infect meat and one form may infect fish. Beef may transmit the *Taenia saginata* (Figs. 1 and 2), 15 to 20 ft. long; pork may contain the *Taenia solium* (Fig. 3), 6 to 12 ft. long; and such fish as the sturgeon, pike, perch, and salmon of certain regions may contain the *Bothriocephalus latus,* 25 to 30 ft. long.

All tapeworms consist of a head provided with hooks and suckers by which they obtain a hold within the intestinal mucosa and a long chain of segments united behind the head. Within the segments there develops a uterus containing a large number of eggs.

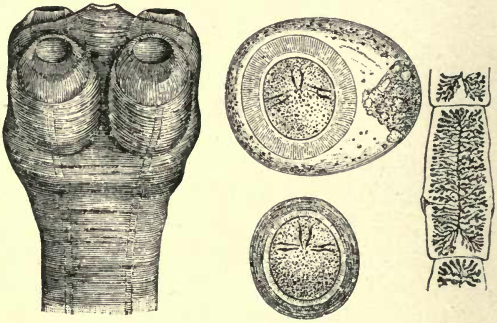


Fig. 2. Head, egg and neck of taenia saginata. (Jaksch.)

These become fully developed in the most posterior segments which break off and are passed out with the feces. The cow, pig, or fish, eating contaminated grass or drinking contaminated water become infected by these eggs. The coating of the egg becomes dissolved in

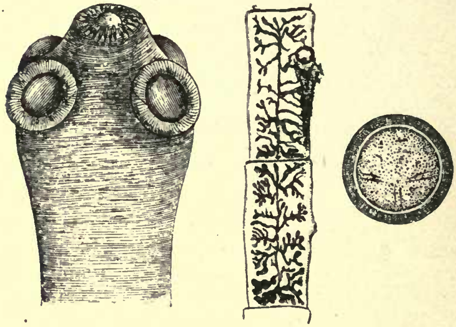


Fig. 3. Head, neck and eggs of taenia solium. (Jaksch.)

the stomach and the minute worm inside begins to bore through the intestinal wall and, reaching the circulation, makes its way to all the muscles of the body. Within the muscles they form little bladders 1-25 to 3-4 of an inch in diameter. These are known as *Cysticerci.*

Trichina Spiralis—Another parasite infecting and obtained from the flesh of pigs is the *Trichina spiralis* (Fig. 4). This worm is far more dangerous than the tapeworm. In the pig the worm is encapsulatedly coiled within the muscles, especially the muscles of the diaphragm, the intercostal muscles, and the jaw muscles (Fig. 5). It appears as a small white speck.

When the flesh is eaten the worm is liberated in the stomach of the human being. Within the intestinal tract, the worm becomes sexually mature and grows as large as a fine thread just visible to the eye. Here the female produces its young and as many as 500 new larvæ may come from one individual worm. These then begin to bore through the intestinal wall reaching the circulation and finally, carried to the muscles, the embryos become incysted. During the migration of the worm from the gastro-intestinal canal to the muscles, the infected individual suffers serious symptoms, not infrequently resulting in death and protracted at times over a period of 2 to 6 weeks.

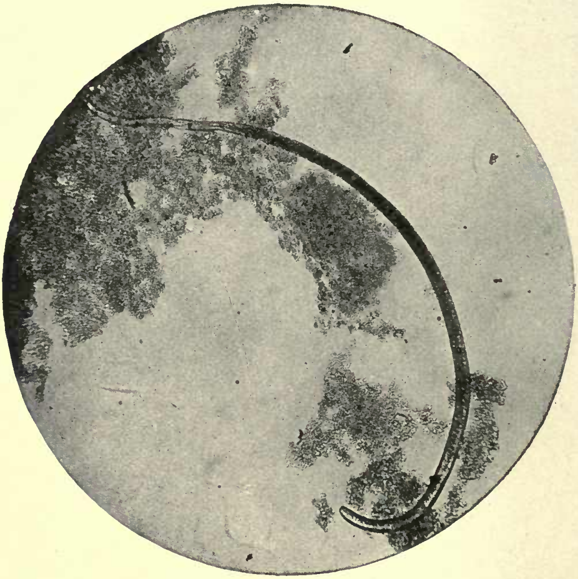


Fig. 4. Free trichina. X 38. (Harrington.)

Bacterial Contamination of Meat—Meat may be unfit for use

because of the bacteria which it may contain. Some of these bacteria are pathogenic bacteria capable of living within the human body and causing there a specific infection. Other bacteria are harmful not because they produce a specific disease within the human being, but because they produce poisonous substances in the meat itself. These toxic substances are derived from the protein of the meat which becomes split into soluble poisons called ptomaines.

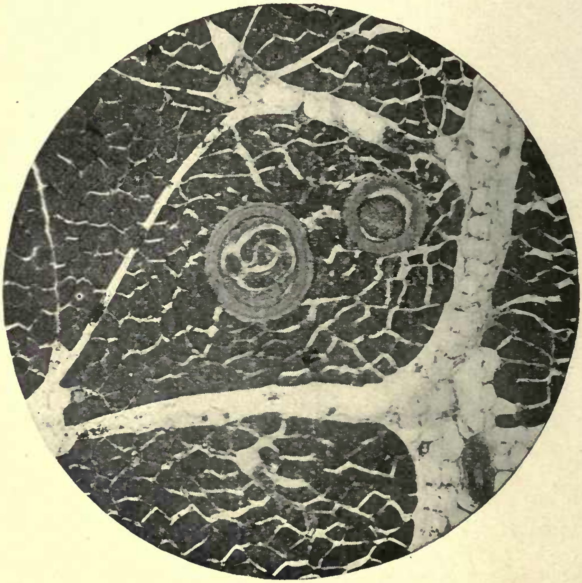


Fig. 5. Trichinae in pig muscle. X 75. (Harrington.)

Tuberculosis—Among the disease-producing organisms transmitted by meat, tuberculosis is doubtless of the greatest importance. The relation of bovine tuberculosis to human tuberculosis has already been discussed in the section on bacteriology. While the *tubercle bacillus* does not infect cattle, the bovine variety of the *tubercle bacillus* constitutes a very real danger to human beings, and especially to children. The abdominal and glandular forms of tuberculosis are frequently of bovine origin.

In Berlin during the year 1892-1893, 15.1 per cent of the cattle, 1.55 per cent of swine, 0.11 per cent of calves, and 0.004 of sheep

had tuberculosis. In Great Britain 30 per cent of the cows are estimated to have had tuberculosis. In Mexico 33 per cent of the cattle slaughtered had tuberculosis. In New York State not more than 1 per cent and 2 to 3 per cent of Jersey or Guernsey cows have the disease. Throughout the United States, on a rough average, about 10 per cent of the cattle respond to the tuberculin test.

Because of the fact that the muscles are rarely affected, the danger of eating tuberculous cattle is not very great. In consequence, various rules have been adopted in various countries. The Royal Commission in England permits the use of tuberculous cattle for food if care has been used in the dressing of it. The French do not permit the use of infected animals if the tuberculosis is generalized. In Prussia the meat of emaciated animals is not allowed to be used for food.

In the United States meat of tuberculous animals is considered unfit for use as food, if, first, it contains *tubercle bacilli* or is impregnated with toxic substances, or if associated septic infections are present in the animal; second, if the animal is emaciated and has generalized tuberculosis. The presence of isolated and few lesions does not render it unfit for use as food. Although the muscles of tuberculous animals do not often contain the tubercular lesions, it has been abundantly proved that other animals may be infected by feeding them upon the meat of tuberculous cattle: and the injection of the expressed juices of the muscles of tuberculous animals into guinea-pigs has caused infection of the guinea-pigs in a fair proportion of instances.

There can be absolutely no question about the very real danger of drinking milk from tuberculous cows and, for this reason alone, rigid examination of all cows used as a supply of milk should be made by the tuberculin test and all animals responding positively should be killed.

Typhoid Fever and Cholera—These diseases are frequently transmitted by oysters and cockles and sometimes by clams. A number of important outbreaks of typhoid fever have been directly traced to the eating of oysters contaminated by allowing sewage to flow over their beds. In an oyster, the typhoid *bacillus* will live for two or three weeks. Oysters may, therefore, be purified by keeping them in pure water two or three weeks after digging.

No oysters are, however, fit to eat which have come from waters

contaminated by human discharges or the refuse from collecting boats. Moreover, oysters should not be transported in open scows through polluted waters.

Ptomaine Poisoning—Meats may become dangerous because they contain virulent poisons called ptomaines. These are manufactured in them by specific though not pathogenic bacteria which have contaminated the meat during the time of the keeping after killing. The possibility of the meat containing fatal quantities of these poisons depends solely upon the introduction into it of the proper bacteria. It does not necessarily bear a relation to the stage of decomposition in meat though unquestionably spoiled meat is far more dangerous.

A number of these poisons have been isolated. They are neurin, cholin, and one identical in action with muscarin, neuridin, putrescin, cadaverin, and another identical in its action with curare.

Though these poisons are primarily formed in the meat before it is eaten, there is no reason to believe that the bacteria responsible for them cannot continue the production of more poison within the intestinal canal, and it is not known in how far this may be the case.

A certain number of these bacteria closely resemble the paratyphoid *bacillus.* Many are spore forming *anaërobes.* Among others which have been isolated are the *bacillus botulinus,* the *bacillus enteritidis sporogenes coli,* the *bacillus enteritidis,* the *bacillus bovis morbificans,* the *bacillus marsiliensis,* the *bacillus Friedenbergensis mirabilis,* the *staphylococcus pyogenes aureus.* The *bacillus botulinus* produces an exceedingly virulent poison causing symptoms resembling those produced by diphtheria and tetanus toxins. Sausage meat is liable to contain these poisons, if care is not exercised in its manufacture.

The symptoms of ptomaine poisoning come on with great suddenness within 3 to 36 hours, and sometimes not until from 2 to 9 days. In the latter case they are probably due to the multiplication of the bacteria within the intestinal canal. The same cause renders infected individuals liable to relapse. The symptoms are characterized by great abdominal pain, diarrhea, vomiting, extreme prostration, anuria, and even paralysis. The meat of animals dying of pyæmia, pleural pneumonia and puerperal fever is especially dangerous.

Eggs—The whole hen's egg contains:

65.5	per cent water
11.9	per cent protein
9.3	per cent of fat
9	per cent of salts

and per lb. they contain 635 calories.

The white of an egg contains:

	Water	Protein	Fat	Ash		Calories per lb.
	86.2	12.3	.2	.6	per cent	250
The yolk	49.5	15.7	33.2	1.1	" "	1,705

In regard to digestibility the white of the egg is more digestible raw or soft boiled; while the yolk is more digestible when hard boiled; so that there is little difference between soft and hard boiled eggs from the standpoint of digestibility. Eggs are far more appetizing when fresh and probably, therefore, more digestible. Unless, however, spoiled, so that they simply cannot be eaten, stale eggs are not harmful to the health as they are not subject to contamination.

Milk—Milk is usually obtained from cows. It should not be used as food for fifteen days before calving nor until ten days after. It should not contain less than 8.5 per cent of solids and 3.25 per cent of milk fat. Cow's milk contains:

	Water	Protein	Fat	Sugar	Mineral matter	
	87	3.30	4	5	.70	per cent
Human milk contains:	87	2.29	3.78	6.21	.31	" "

Two important proteins occur in milk casein and lactalbumin. The mineral matter consists chiefly of the phosphates and chlorides of potassium, sodium, calcium, magnesium and iron.

The phosphates are in excess of the chlorides and the potassium salts in excess of the sodium salts.

The specific gravity of milk should vary between 1.029 to 1.034.

In the early days of lactation the sugar in milk is dextrose and not lactose.

Milk contains a number of ferments, trypsin, pepsin, amylase (not in cow's milk), lipase, and reductase.

Bacterial Contamination of Milk—Fresh milk is said to inhibit the growth of bacteria, but this property of milk is soon lost, and it is the bacteria, which kept milk may contain, that render it dangerous to health.

When once started, bacteria multiply with great rapidity in milk. It forms a most valuable culture medium for bacteria. The conditions under which milk is obtained preclude prevention of the entrance of bacteria into it.

Microscopical study of thirty-five teats of cows showed that not one was free from bacteria and that these belonged chiefly to the class of pyogenic bacteria. Similar results have been obtained by the examination of cow's udders. Even with every precaution against contamination during milking, precautions which include washing the cow's legs, tail, udders and teats, a thorough washing of the hands of the milking man and a careful straining of the milk through sterile strainers, the freshly drawn milk will contain on the average 242 to 267 bacteria to the cubic centimeter. It is true that one-third of the samples drawn under these conditions showed no bacteria, but one-tenth of the samples contained more than 5,000 to the cubic centimeter.

When freshly drawn milk contains a large number of bacteria, the bacteria are chiefly of intestinal origin and belong to the lactic acid ferment producers. The most important one is the *streptococcus lacticus,* which is probably only a variety of the *streptococcus pyogenes.* Another is the *bacillus acidi lactici,* which is probably identical with the *bacillus lactis aërogenes.*

Other bacteria belong to the *bacillus coli communis* group. Some twelve varieties of peptonizing ferment-producing bacteria have been isolated from milk. Three of these are seriously pathogenic to animals. A butyric acid ferment-producing bacterium has been isolated. They are strictly spore-forming anaërobes and include among them the *bacillus enteritidis sporogenes* or the *bacillus aërogenes capsulatus.*

Provisions for Obtaining Pure Milk—Many milking devices have been made which are designed to draw milk in a manner which will prevent hands coming in contact with the cow and at the same time will exclude all external sources of contamination. None of them, however, have been found successful. For some unknown reason

their use has been accompanied by a reduced production of milk by the cows.

The best that can be done in order to procure uncontaminated milk is to milk into a scrupulously clean pail, completely covered, with the exception of a sieve-covered opening 6 in. in diameter through which to receive the milk; to keep the cows and their stalls clean; to wash their udders and teats before milking and above all to thoroughly cleanse the hands of the milkers before milking and insist upon their wearing clean clothes during milking. After milking, the care with which the milk is bottled and kept will have much to do with its bacterial content. Milk obtained from healthy cows with care and only containing, approximately, 6,000 bacteria to the cubic centimeter, within a short time after milking will contain, even if kept at 45° F., increased numbers—in five hours' time it will contain 1,933 bacteria to the cubic centimeter, and in 48 hours' time it will contain 17,816 to the cubic centimeter.

Milk obtained with only ordinary precautions contains to each cubic centimeter:

	In the winter	In the summer	
Shortly after milking	16,650	30,366	bacteria
After 24 hours	31,000	48,000	"
After 48 hours	210,000	680,000	"

Twenty samples of milk, some of which had come from a distance of two hundred miles, contained, immediately on arrival in the city, 52,000 to 35,200,000 bacteria to the cubic centimeter. The average was 5,669,000. The lactic acid producing bacteria exert an inhibitory effect on the growth of most of the other bacteria in milk and develop better than other varieties at low temperatures, below 40° F., for instance. They entirely inhibit the growth of many other bacteria originally present in milk. On this account while the number of bacteria increase in milk with time, the number of varieties decrease. The question of sterilization and Pasteurization of milk has already been discussed in the section on bacteriology. Neither process is desirable when they can be dispensed with. Neither is the use of such preservatives as formaldehyde or salicylic acid desirable. The least objectionable preservative is, perhaps, hydrogen peroxid though this is only temporary in its effect. A 0.2 per cent of a 3 per cent solution of hydrogen peroxid

will sterilize milk and a 1 per cent will keep it fresh for one week. The stinging taste, however, is perceptible in .01 per cent of hydrogen peroxid. The only unobjectionable and reliable way of keeping milk pure is to obtain it under conditions which are scrupulously cleanly and to keep it at temperatures which are at least only a few degrees above the freezing point.

An important source of adulteration of milk is water, which is sometimes used for dilution purposes. The farmer's pump has been responsible on more than one occasion for typhoid fever.

Condensed Milk—Condensed milk is milk evaporated to 1-3 of its volume and sweetened with cane sugar. If sufficient fat should be added to bring its content of fat up to the fat standard for milk, it would raise the cost of condensed milk to 9 to 12 cents a quart. Inasmuch as condensed milk cannot be heated during its preparation to a sufficiently high temperature to kill the bacteria which it contains, without caramelizing the sugar, it usually contains a large number of bacteria. The number of bacteria present has been 900 to 10,000,000 to the cubic centimeter.

Butter—Butter is the separated fat of milk. Good butter should contain as follows:

84 per cent of fat
12 " " of water
1 " " of cocein lactose
.5 to 2.5 per cent of salts.

The fats are chiefly trioleates, palmitates, and stearates, which together compose 92.25 per cent of the fats of butter. Fats of other fatty acids are present and to these are due the flavor and odor of the butter. The most important of the other fats are the compounds of butyric, caproic, caprylic, and capric acid.

Oleomargarine butter is butter manufactured from the fats of beef and lard which also contains the fats of oleic, palmitic and stearic acid. Oleomargarine butter is, therefore, good butter and the prejudice against it is entirely unwarranted. Natural butter is, of course, liable to the same kinds of contamination as milk and hence may be the source of similar dangers.

Cheese—Cheese is the coagulated casein of milk pressed into forms and ripened by inoculation into it of various organisms (enzymes, molds, bacteria) which grow through it until limited by

the products of their own growth. It is the products of the growth of these organisms so inoculated into it which impart different flavors to the varieties of cheese.

Cheese should contain 50 per cent proteins (casein) and 30 to 35 per cent of milk fat.

Cheese may become accidentally infected with an unknown organism which is capable of producing a violently poisonous ptomaine called tyrotoxicon. This same ptomaine has been found responsible for many cases of poisoning from milk and ice cream. The poisonous symptoms are accompanied with the violent gastro-intestinal symptoms of vomiting, nausea, abdominal pains, diarrhea, and marked prostration.

Vegetable Foodstuffs—Vegetable foodstuffs may be divided into the following:

1. Farinaceous seeds which include—
    a. The cereals;
    b. The legumes.
2. Farinaceous preparations.
3. Fatty seeds (nuts).
4. Vegetable fats.
5. Fibers and roots.
6. Herbaceous articles (vegetables).
7. Fruits used as vegetables.
8. Fruits in the narrower sense.
9. Edible fungi.
10. Saccharine preparations.

The Cereals—The cereals include wheat, rye, barley, oats, corn, buckwheat, and rice. These all contain about:

10 per cent of moisture
12 per cent of proteins
1.5 to 6 per cent of fat
50 to 70 per cent of starch.

Wheat—The proteins of wheat are albumin, proteose, gliadin, and glutamin. The last two form 80 to 90 per cent of the proteins of wheat. They unite in the presence of water to form a paste called gluten, and the nearer the proportions of the gliadin to

the glutamin to the ratio of 25 gliadin to 75 of glutamin, the better is the flour from the wheat for bread-making purposes. The carbohydrates in wheat are cellulose, sugar, dextrin, and a number of unimportant carbohydrates. The starch is in the form of granules .002 to .05 millimeters in diameter in which the starch is imprisoned in concentric rings of cellulose which must be ruptured by boiling in water before the starch is liberated. High grade and more thoroughly bolted flour is poorer in proteins and fats and richer in starch than the less thoroughly bolted flour. However, the unbolted flour is not necessarily more nutritious but contains rather more of the indigestible residue. This residue is somewhat more irritating to the gastro-intestinal tract and in virtue of this character it is believed to act more favorably in patients troubled with constipation than the purer high grade flours.

Macaroni—Macaroni is made from a special variety of wheat which yields much gluten. The best wheat for macaroni is obtained from Algeria or Russia. The American wheat is not rich enough in gluten and too rich in starch. The chief adulterations of wheat are magnesium, carbonate, gypsum, chalk, alum, and nitric and nitrous acids, formed by nitrogen peroxid used for bleaching purposes. Adulterants are to be recognized by the microscope and the question whether flour has been bleached or not by the fact that the gasolin extract of unbleached flour is yellow.

Rye—The proteins of rye closely resemble those of wheat, but yield less gluten. Its nutritive value is about the same as that of wheat.

Barley—Barley yields no gluten. When it is deprived of its husks and polished, it is known as pearl barley. It is used chiefly in the manufacture of beer. In the manufacture of malt from barley, a peculiar product is formed which converts starch into sugar.

Oats—Oats are comparatively rich in vegetable fats and crude fiber. They contain 12 per cent of proteins, but only 58 per cent of starch. They yield no gluten but can be used to make very palatable cakes and cereals. They exert a mild laxative action, probably from their content of crude fiber.

Corn—From corn are made several food products. It is eaten from the cob or boiled after cutting from the cob.

Hominy—Hominy is corn after removing the hulls by soaking.

Samp—Samp is the whole kernel of corn minus the gum and the hull.

Indian meal is prepared by grinding the whole kernel and bolting more or less of the bran.

The proteins of corn include several globins, myosin, vitellin, and two special albumins and two zeins.

Rice—Rice constitutes the main article of the diet of one-third of the human race. It is usually sold in the form of polished rice, that is with the reddish cuticle removed. It has rather a low amount of both protein (7.50 per cent) and fat (40 per cent). It is rich in starch and is easily digested. It is best not to cook it by boiling, which removes some of the naturally deficient proteins. In preference it should be cooked by steaming.

Buckwheat—Buckwheat is the most expensive of the cereals and, therefore, most apt to be adulterated. Natural buckwheat contains 10 per cent of crude fiber, which is almost wholly removed by the milling in the conversion of buckwheat into flour.

Legumes—Include peas and beans, both string and lima beans and the soja bean and lentils. The main character of the legumes is the large percentage of proteins which they contain. The chief protein is legumin, a protein closely resembling casein.

The proteins in legumes are as follows:

Legumin	60.95	per	cent
Glutamin	30.65	"	"
Albumin	0.64	"	"
Gliadin	7.75	"	"

While most of the legumes have a high nutritional value, they are somewhat difficult of digestion and at least 1/3 to 1/5 is lost in the excreta. They contain considerable sulphur which may induce flatulency.

In general the legumes contain:

Water	10 to 15	per	cent
Proteins	23 to 25	"	"
Fat	1 to 2	"	"
Starch	45 to 55	"	"

Dried peas and beans lose much of their value by the prolonged soaking which is necessary and their flavor is not nearly so delicious.

Canned peas and beans contain much less nourishment. Canned peas contain only:

3.6 per cent of proteins
.2 " " of fats
9.8 " " of carbohydrates.

String beans, of course, contain only a small amount of nourishment. They have as follows:

2.3 per cent of proteins
.3 " " of fats
7.4 " " of carbohydrates.

The soja bean is remarkable for the high percentage of protein (33 per cent) and fat (17 per cent) which it contains. It only contains 30 per cent of starch.

Lentils are a most nutritious legume and their more general use should be encouraged. They contain:

25 per cent of proteins
53 " " of starch
but only 1.89 per cent of fats.

Farinaceous Preparations—Farinaceous preparations include sago which is the pith of certain palm stems, and the tapioca or the thick fleshy tuberous root of the manihot, and arrowroot which is a pure form of starch derived from the tuberous root of the maranta. These preparations are easily digested but are almost solely starchy foodstuffs.

Nuts—Nuts are rich in fats and oils and in consequence contain a high nutritive value, but they are not easily digested. Almonds, cocoanuts, walnuts, and peanuts contain 45 to 70 per cent of fats and 15 to 16 per cent of proteins. The cocoanut contains 7 per cent of sugar. The chestnut, which is not a true nut, contains little fat, 15 per cent of sugar, and 25 per cent of starch. It is, therefore, indigestible.

Tubers—Tubers include white potatoes, sweet potatoes, and artichokes. Both varieties of potatoes have relatively very little protein (2 per cent) and also in starch (18 to 27 per cent). Artichokes contain twice as much protein (4 per cent), no starch, but 15 per cent of sugar.

Roots—Roots include a whole group of foodstuffs, such as beets, carrots, oyster plants, parsnips, radishes, and turnips. They all contain:

80 to 90 per cent of water
1 to 1.5 “ “ of proteins
10 to 15 “ “ of carbohydrates
.1 to .5 “ “ of fats.

Herbaceous Vegetables—Among the herbaceous vegetables are asparagus, cabbage, cauliflower, sprouts, celery, lettuce, spinach, beet tops, dandelion, leeks, and onions. These contain:

90 per cent of water
1.5 to 2 per cent of proteins (sprouts contain 4.7 per cent)
3.0 to 5.0 per cent of carbohydrates (onions and dandelion contain 10 per cent)
.3 to .5 per cent of fats (asparagus contains 3.3 per cent)

They contain little of the essential foodstuffs but are valuable for their salts and laxative effects.

Fruit Vegetables—Fruit vegetables include tomatoes, cucumbers, squash, pumpkins, egg plants, and vegetable marrow. They all contain little nutritive value, about 90 per cent of water and less than 1 per cent of proteins.

Fruits—The fruits include apples, pears, peaches, apricots, plums, prunes, cherries, oranges, grapes, and melons. They contain:

80 to 85 per cent of water
.4 to 1 “ “ of protein (the majority less than 5 per cent)
5 to 10 per cent of sugar.

Though they possess little of nutritive foodstuffs, they are valuable alteratives, because of the rich contents of organic acids (about 1 per cent) and salts. They are slightly laxative.

Bananas and Figs—Bananas, plantains, and figs are the most nutritious fruits. They contain 2 per cent of proteins and 20 per cent of sugar; figs contain 4 per cent of proteins and 50 per cent of sugar.

Berries—The various berries, blackberries, cranberries, currants, gooseberries, huckleberries, mulberries, raspberries, strawberries, have all about:

85 per cent of water
5 to 10 per cent of sugar
0.5 per cent of proteins (strawberries 1.07 per cent)

Mushrooms—Mushrooms are composed chiefly of fiber. They contain 12 per cent of solids, of which nitrogenous compounds form a large proportion. This nitrogen, however, is chiefly in the amino acid form probably and, therefore, is not available to any large extent for assimilation. At least it is not known how many of the amino acids of the protein foodstuffs are contained in mushrooms. The high nutritive value formerly attributed to mushrooms is probably not to be obtained from them.

TEA, COFFEE, AND COCOA

Tea—The different varieties of tea depend chiefly upon the age of the leaves when gathered and the method of drying and preparing them. The choicest teas are the youngest terminal leaves of the plants.

Green teas are obtained from young plants roasted soon after gathering. Black teas are the coarser older leaves dried for ½ a day and then rolled and roasted. Tea contains:

21.22	per	cent	of nitrogenous substances
.67	"	"	of volatile oil
1.35	"	"	of thein
3.62	"	"	of fat
7.13	"	"	of gum dextrin
12.36	"	"	of tannin
16.75	"	"	of extractives
20.36	"	"	of fiber

The important principle is thein, which produces a definite physiological action upon the body. In the preparation of tea, the method of drawing is all-important. The first drawing with hot water makes the most delicious beverage and contains the least tannin. Steeped or boiled tea contains much tannin which both imparts a bitter taste and increases its indigestibility.

Coffee—The world's annual consumption of coffee amounts to 900,000 tons and of this the United States consumes one-third. In

coffee the caffein, which is the same as thein, is intimately associated with tannin. When toasted at 200° C., the two are disassociated. The sugar is changed to caramel and certain aromatic principles are developed. The roasting of the coffee must be carefully done, otherwise the flavor of the coffee will be impaired by the draining off of certain of the isolated principles. Weight by weight, coffee really contains less thein than tea. Coffee contains .64 to 2.21 per cent; tea contains 1.36 to 3.09 per cent.

Coffee contains as follows:

.64 to 2.21 per cent of thein
12 per cent of fat
40 " " of fiber
and traces of sugar and gum.

The question of the relative physiological effect produced by coffee and tea is not to be decided by the relative amounts of thein contained by each. So much depends on the strength of the drawn tea or coffee and the quantity consumed that the relative amounts of thein in each is a guide of small value. Both, however, produce a definite physiological action. Each individual must be his own guide as to the quantity of each of the beverages which he drinks. It is certain, however, that the desirable limit is easily overstepped and that as a consequence many individuals suffer a train of unpleasant symptoms both neurotic and digestive in nature, which seriously handicaps their efficiency.

Coffee is easily and frequently adulterated. Almost all the adulterated varieties contain starch which is easily detected by the iodin test. Coffee itself contains no starch. The preparation known as De Kafa contains about 1/5 of the usual amount of caffein.

Cocoa—Cocoa is obtained from the bean of the cocoa plant. This bean is one of 4 to 10 beans about the size of almonds occurring in 5 rows in a pod which measures 1 foot long by ½ foot wide.

When ripe, the pod is gathered and allowed to ferment for 24 hours or more. They are then opened and the seeds removed and allowed to ferment longer in holes or earthenware vessels. The seeds are then dried.

For the market the seeds must be carefully cleansed and roasted. During the roasting, the husks come off and the seeds are crushed

slightly and then freed from the husks and hardened (germs). They are then ground into a paste and allowed to harden into cakes. These cakes are chocolate.

To prepare cocoa some of the oil of the chocolate is removed by hydraulic pressure, and the residue is passed through a very fine sieve.

Unlike tea and coffee, cocoa is relatively very nutritious. Its active principle is theobromin, which closely resembles thein.

Cocoa contains:

3.63	per	cent	of water
13.49	"	"	of proteins
49.32	"	"	of fat
13.25	"	"	of starch
13.18	"	"	of extractives
3.65	"	"	of fiber
3.48	"	"	of ash.

The amount of the theobromin averages 1.50 per cent. It is less stimulating and more diuretic than thein. Compared to tea and coffee in the usual strengths in which these beverages are taken, cocoa is far weaker in its physiological action and a much more wholesome beverage.

The husks of the cocoa bean make a cheaper but, nevertheless, a very wholesome product.

The Preservation of Foods—The preservation of food may be accomplished by several methods.

Cold—The best preservative for food is cold slightly above the freezing point of water. Meat, fish, and eggs, etc., will all keep in dry air at this temperature. Care should be taken that the temperature is uniform. Alternate thawing and freezing does impair the quality of the food. The production of the cold by the ammonia process is good provided that the food is in air-tight spaces in order that the ammonia does not penetrate into it. Packing in ice only answers for a short period.

Drying—Drying is efficient according to its thoroughness. It may be used for meats and vegetables. It does not insure safety against parasites and impairs the flavor and the digestibility of the food.

Salting—Salting also impairs the flavor and digestibility of the food.

Smoking—In smoking, some of the creosote and other substances of the wood consumed penetrates the food; or the meat, in the quick process, is brushed over, or dipped in pyroligneous acid at intervals and dried in air. It seriously impairs the value of the food in its digestibility and flavor.

Canning—Canning is an excellent method of preserving food. The food is packed in cans and then sealed except for a very small hole. The can and its contents are then raised to the boiling point of water or higher for 1 hour and the hole closed. They are then reheated. There is no good evidence that the action of the food on the metal corrodes it sufficiently to produce the slightest harm to the individual eating its contents. Canned goods have stood the test for 5 to 10 years in many instances, and have always been found in good condition.

Chemical Preservatives—The use of chemical preservatives includes the use of boric acid, borax 1 to 500 or 1,000, salicylic acid 1 to 1,000, sodium sulphate 20 per cent, formaldehyd 1 to 5,000, hydrogen peroxid 1 to 1,000, all of which are not infrequently used. And in addition some 35 other preservatives. All of them are to be condemned from a standpoint of altering the food, its digestibility, and many of them become indirectly irritating to the stomach.

Contamination of Food by Metals—Food is often contaminated by various metals. The various acids or alkalis in the food being responsible for dissolving off a certain quantity of the metal.

Lead—Of all the metals, lead is the most important. Tin foil may contain lead in quantities varying from traces up to 89 per cent. The metallic caps for preserving fruit may contain 93.5 per cent of lead. The contents of sealed bottles may yield as much as 1.05 milligrams. Lead is commonly dissolved by preparations containing carbon dioxid, tartaric or citric acid. It may, therefore, be present in baking powder, in summer drinks or in beer. The highest amount found in such preparations was .037 per cent. Canned foods are now not likely to contain lead. Unquestionably the daily ingestion of small quantities of lead is dangerous. It is illustrated by the lead colic not infrequently met with in painters who are not careful to eat with well-washed hands. As regards

lead in food from other sources, acid drinks in bottles with lead stoppers are to be particularly avoided, or beer transported through lead pipes.

Copper—Copper may be picked up from copper cooking vessels. Thirty-six and eight-tenths milligrams of copper were found to the liter of broth which stood for 24 hours in copper vessels, and 21 milligrams in 100 cubic centimeters of rancid fat standing for two weeks.

Copper is sometimes used as a component of those preparations employed for greening vegetables. Thirty-nine milligrams of copper have been taken daily for fifty days without harm. Its complete excretion may occupy five months. Copper appears to be a normal constituent of certain vegetables. Little danger can come from it when taken in small doses. For a considerable length of time it is completely excreted. Probably larger doses are not absorbed.

Zinc—Zinc was formerly a contamination of canned goods and came from the flux used in the soldering of the can. At present an improved method with another flux is used. Acid substances may extract zinc from galvanized iron. It has been a rather common contamination of dried apples which have picked it up from the rocks on which they have lain; .03-.49 milligram to the kilogram has been found. In these amounts it has no sanitary importance.

Nickel—Nickel has been used in place of copper for greening peas in the proportion of ¼ of a gram to a kilogram of peas. It is said to be given off from nickel dishes in which food is cooked. Traces up to 12.9 milligrams have been found in 100 grams of food. There is no evidence that these amounts can produce injury.

Tin—Contamination with traces of tin is common but so far as it is known it seems harmless.

AIR

Composition—Air contains about 21 per cent of oxygen and 78 to 79 of nitrogen, traces of hydrogen (.015 per cent) and argon 75 per cent, varying quantities of ozone and ammonia, and, though present in very small quantities, but yet of extreme importance, .03 per cent of carbon dioxid.

The nitrogen simply dilutes the oxygen in the air. It and argon are inert. Although much of hygienic importance has been claimed for ozone, and for the value of inhaling air containing ozone, and for the purifying effects of ozone in air, yet no practical evidence exists that it possesses any significance. Ozone is very irritating to mucous membranes. If inhaled in proportions of 1:240 it will quickly produce death in animals.

All life, directly or indirectly, depends upon the oxygen and carbon dioxid in the air. The oxygen is consumed by plants and animals alike and used for the production of energy.

Man inhales 7 lbs. of oxygen in 24 hours. Of this the lung absorbs 2 lbs.

The Production of Carbon Dioxid—From the carbon dioxid in the air the plants build up the organic compounds of carbon which form the foodstuffs of animal life. The chief sources of carbon dioxid in the air are respiration, fermentation, and compression. A normal animal exhales 20 liters of carbon dioxid per hour.

Every ton of coal consumed yields 67,000 cubic feet of carbon dioxid. Every cubic foot of coal gas consumed yields twice its value of carbon dioxid. From all sources probably 5,000 million tons of carbon dioxid are added yearly to the atmosphere. The ocean contains about ten times the amount of that in the atmosphere.

The forces tending to withdraw carbon dioxid are doubtless far greater than those contributing it. Untold quantities are locked up yearly as insoluble carbonates by the coral- and shell-producing invertebrates of the sea. The quantities washed down by rain unite with the alkali earth metals and become insoluble. The total respiratory contributions of carbon dioxid are small as compared to the chlorophylian function of plants.

An acre of land withdraws 4½ tons and returns 3¼ tons. The remaining ton is, of course, at some future date in the returned process of combustion of the substances, formed from the retained carbon dioxid.

The Possibilities of Varying the Percentage of Carbon Dioxid in the Respired Air—An increase of the normal tension of carbon dioxid in the blood is accompanied by alterations of some of the most important physiological functions of the body and is not tolerated until the compensating mechanism is overpowered. It

is possible for the compensating mechanism to keep the blood tension of carbon dioxid normal (40 millimeters of Hg.) in the presence of considerable variations in the amount of carbon dioxid in the external atmosphere. The percentage of carbon dioxid in the air may be increased to 5 per cent without seriously altering the percentage in the alveolar air, though to keep this, constant respiration will be increased to 20 a minute. It is generally held that carbon dioxid is not harmful when it is increased to 20 parts per 10,000 or 0.2 per cent. In fact, many instances are known in which the carbon dioxid has been increased to 43.20 (.4 per cent) and even 100 parts (1 per cent) per 10,000 without ill effects. A room generally does not begin to feel close until the carbon dioxid content reaches 10 parts per 10,000. The permissible high limits are generally regarded as 6 or 7 parts per 10,000. When the quantity of carbon dioxid reaches 15 parts per 10,000, the occupants of the room may begin to suffer from headache.

It is certain that the carbon dioxid itself is not the cause of this headache or the depressed and uncomfortable sensations which accompany high percentages of carbon dioxid in the air breathed. The ill effects have been attributed to poisonous organic matter which is exhaled from the breath and from the skin of the individuals crowded together and which is responsible for the increase of carbon dioxid. The increase of carbon dioxid from 6 to 7 parts per 10,000 is adopted as a guide not so much to the permissible limits of carbon dioxid in the air as because, accompanying any increase of carbon dioxid in the air the air becomes objectionable for other reasons.

Explanation of the Toxic Effect of a Close Atmosphere—It has been said that the various other objectionable features are the various organic exhalations, but no toxic substances of this nature have ever been isolated from vitiated air. According to the latest view, the harmful effects of deficient ventilation are due rather to the increased temperature and moisture of the air which has been contaminated by the increase of the carbon dioxid content to 6 or 7 per cent. In order to replace the air in a room containing 1,000 cu. ft., at a sufficient rate to keep the carbon dioxid down to 0.07 per cent, 2,000 cubic feet of fresh air should be supplied for each individual occupying the room every hour, inasmuch as each individual gives off .6 cubic feet of carbon dioxid every hour.

Air almost always contains a certain percentage of water. Water vapor is lighter than air and is very unequally diffused. Every adult may give off 4 lbs. of water from the skin and lungs during the 24 hours. This source of increase of moisture in the air is an important reason for the toxic effect of overcrowded rooms.

Function and Effects of the Water in the Atmosphere—An enormous quantity of water is added to the atmosphere by plant life. Each healthy tree contributes a great deal. Every plant contributes 250 to 400 times the weight of the dry organic matter added to the plant at the same time. At 0° C. air takes up 1/160 of its volume of water and at each increase of 15° C. it takes up twice as much more.

The quantity of moisture in the air greatly influences the rate of elimination of water from the body. At 15° C., in moist air, the daily elimination of water is 216 grams. When the air is dry, at the same temperature, the elimination is 871 grams. The water vapor in the air performs a very useful purpose, preventing the rapid cooling of the earth at night.

In hot air saturated with moisture, the evaporation of the perspiration is slow and the radiation of heat from the body is slow. It is for this reason that the heat becomes oppressive in damp weather. Saturation, however, in cold weather has almost as great an influence on bodily comfort. The water vapor makes the air a better conductor of heat and for this reason one feels the cold intensely when the air is damp in the winter time. When this is the case we are accustomed to say that it is cold and penetrating. On the other hand in the coldest weather when the air is dry, no particular hardship is experienced.

Dust and Bacteria in the Atmosphere—Dust, organic and inorganic, of all dimensions is ubiquitous in the air. Microörganisms are very abundant in the air of inhabited rooms and towns. At high altitudes, 6,300 feet above sea level, no microörganisms are found. Over the ocean 120 miles from land, the air is free from organisms and at 90 miles out it is comparatively free from microorganisms. In London it is calculated that an individual inhales 4,000,000 bacteria per hour. This number, however, is probably very large and even so corresponds only to the number of bacteria in 4 cubic centimeters of milk. At Montsouris the average number

of bacteria, in an investigation which extended over a period of 6 years, was only 455 per cubic meter. During the same period the number in the air in the center of Paris was only 3,910. While the number of bacteria in the air appears to be high, it must be remembered that the vast majority are not pathogenic.

Nevertheless, in the vicinity of the sick, sufficient pathogenic bacteria may float in the air to constitute a real source of danger. Of no bacterium is this more true than of the *bacillus* of tuberculosis.

The dust in the air, however, serves a very useful purpose. It is very hydroscopic, attracting and holding on to the last vestige of water most tenaciously. Without it the vapor of the clouds would not condense and there would be no rain or fog, but the vapor would simply condense on the surface of the earth and upon those objects upon it.

Gases in the Atmosphere—Of the gases which may contaminate air, there are hydrogen sulphid, sulphuric acid, hydrochloric acid, carbon bisulphid, marsh gas, and carbon monoxid. None of these gases are of much importance except carbon monoxid. It gains entrance to the air chiefly from leaky gas pipes. It has been calculated that in Paris the annual loss of illuminating gas was 15,000,000 cubic meters.

A smaller amount than 0.25 per cent by volume in the air will cause poisoning, and 1 per cent is rapidly fatal. There have been cases of the poisoning of adults from the aspiration of gas into the cellar of a dwelling, 100 feet from a leak in the gas main.

Contamination of the Air by Sewage—Sewage is a frequently alleged source of impurity of air and the contaminated air from sewers is called sewer gas. Its composition depends upon the rate of generation of the gases produced by decomposition of the sewage and upon the completeness of the ventilation of the sewer. It may be quite pure or contain 10 to 30 volumes of carbon dioxid in 10,000. In London there are 51 volumes and in Paris 340. Ten to 30 volumes is not, therefore, an unusual amount. Besides carbon dioxid there are traces of hydrogen sulphid, marsh gas, and compounds of ammonia. Sewer gas also contains bacteria and vegetable débris. Sewage itself is, of course, full of bacteria, 20,000 to 200,000 *coli communis* to the cubic centimeter are frequently present and it is alleged that the rise and fall of water in the sewer leaves

many bacteria high and dry. The bursting of the gaseous bubbles in the sewage and the splashing of the sewage as it passes along its conduits are causes for the contamination of air with many bacteria. Nevertheless, it is true that the sewer gas is bacteriologically purer than the air within the rooms of schools and dwellings. For instance, practically no *colon bacilli* are found in the sewer gas. Moreover, of the bacteria found in the sewer gas, few are of the liquefying varieties.

Unquestionably, the chief reason for excluding sewer gas from dwellings is because of its power to render the air within them disagreeable from an esthetic standpoint. The best authorities are agreed that sewer gas is not capable of transmitting typhoid bacilli and that bacteria are not given off in any significant numbers from the surface of sewage.

It is true that the *bacillus prodigiosus* has been recovered on plates held 10 feet above the traps of inoculated drainage systems and has penetrated all parts of the house in open connection, up to 50 feet in height; yet the amount of air infection, even under extreme conditions, is so slight that one would scarcely expect the general air of sewers and house-drains to be appreciably affected under normal conditions.

Moreover, human beings spending much of their time actually working in sewers are, as a rule, quite healthy and certainly they are not particularly susceptible to infections traceable to sewers.

The Sole Source of Dangerous Contamination to the Air— Under the normal conditions usually met with, we may dismiss in a word all the various means by which it is possible for air to be contaminated from either individuals or sewers, with one exception, as unimportant. This exception is the infection of the air by diseased individuals with specific pathogenic bacteria. It is for this reason chiefly that overcrowding is always associated with ill health and an increase of the air space allowed to each individual has always been associated with a decrease in illness. At one time, for instance, the death-rate in the English Army from phthisis alone was 11.9 persons per 1,000. The introduction of more efficient ventilation and increase of average air space caused an immediate improvement, a reduction of this death-rate to 1.2 per 1,000. The same facts are true of animals left in captivity. The immediate effects of overcrowding are discomfort, oppression, headache, dizzi-

ness, faintness, and nausea. Continued exposure causes pallor, languor, anemia, skin troubles, loss of appetite and in consequence a diminished resistance to disease. As has been explained, these symptoms are dependent chiefly upon the increased temperature and moisture in overcrowded spaces and upon a diminution of oxygen, whenever such diminution occurs, but not upon the increase of carbon dioxid or the collection of any organic poisonous matters given off from the body, called in a vague manner crowd poisons and consisting of epithelium, constituents of sweat (butyric, capric, capronic, caprylic acids, lactate, butyrate and other salts of ammonia) and the volatile matter from foul mouths in which decayed teeth are present and from individuals with poor digestive functions, and the excrementitious matters deposited on unclean clothing, also poisonous matters in the breath.

There can be no question that the air transports bacteria and wherever individuals who have harbored pathogenic bacteria have been living, the air will transport such bacteria and becomes a real source of infection. The possibilities of the transport of bacteria through the air is directly proportional to the quantity of dust which it contains. Dust is very hydroscopic and will hold tenaciously a certain quantity of water. The protection which dust affords to bacteria both in itself and in virtue of its hydroscopic character is an important factor to the transportation of these bacteria.

Tubercle Bacilli in the Air—The bacillus of tuberculosis has been found in an active state in a room 1 year after the death of its occupant. This bacillus has been found in 147 samples of dust collected from hospitals.

In 76 per cent of the cases examined, *tubercle bacilli* were found in the droplets coughed out by tubercular patients. The smallest number of bacilli that were found were 4 and in 1/3 of the cases they were numerous. Dust taken from places likely to be infected were injected into 81 guinea-pigs, a large number of these became infected and died. The dust from the most suspicious rooms was the most fatal, while those pigs inoculated with dust from buildings in which there had been no tubercular inhabitants, did not become infected with tuberculosis.

Typhoid Fever in the Air—Opinions vary as to the danger of contracting typhoid fever from the dust of rooms in which typhoid

patients have been confined. The typhoid bacillus cannot stand drying while the *tubercle bacillus* can stand relatively very complete drying for long periods.

Diphtheria—The diphtheria bacillus, on the other hand, will survive drying for relatively long periods. It is abundant in the mouth and nose of those ill with diphtheria and may persist in a virulent state for long periods after apparent recovery. The dust in the vicinity of those ill with diphtheria becomes contaminated with diphtheria and is a source of danger to others.

Streptococcus—The streptococcus of erysipelas, pneumonia and pyogenic infections resists drying to a somewhat unusual degree so that transmission through the air becomes extremely probable.

Diplococcus—The diplococci also resist drying. The diplococcus of epidemic cerebrospinal meningitis, dried in a handkerchief, has been found to be capable of causing infection 6 weeks after use of the handkerchief by the patient. It is believed to present the greatest resistance to drying.

Cholera—There is not much danger of contracting cholera from dust. They live only a short time when mixed with dry dust.

Dysentery—The organisms responsible for the summer infantile diarrheas of children will survive for relatively long periods and dust and dirty air are important means of spreading these diseases in the cities. In fact, the frequency of these diseases bears an inverse ratio to the amount of rainfall.

In general, however, foggy weather always increases the dust evil, for it supplies a certain quota of moisture to the dust and prevents the absolute drying out of the bacteria. Respiratory diseases, particularly, show an increase during foggy weather.

Smoke—Smoke must be included as an offensive constituent of the atmosphere. It is also objectionable because of its irritating, corrosive, and disfiguring actions, and because of its influence in shutting out the sunlight. The use of methods of consuming smoke in furnaces should be encouraged; moreover, this use is an economy. The best method is the one brought to the attention of the State Department by Consul-General Mason. This process consists of distributing heated and slightly compressed air through hollow grate bars to the whole lower surface of the furnace. The combustion is completed by this method; and inasmuch as the low-grade coals can be used, additional saving can be made.

SOIL

Composition and Classification—Soil is a mixture of minerals, sand, or clay with organic material. Soil is divided into:

1. Superficial soil.
2. Subsoil.

Superficial soil is classified as:

1. *Sandy*—Sandy soil is that of which 4/5 is composed of sand.

2. *Clay*—Clay is composed largely of silicate of aluminum, which is very cohesive. The plasticity of clay is due to a small proportion of silicate of aluminum. The addition of one-one-hundredth part of caustic lime greatly modifies this plasticity. Clay is very impermeable to water and dries with great slowness.

Loams—Loams are mixtures of sandy clays and humus. They partake, therefore, of the characters of the clay and of the humus. When the clay predominates, they are termed heavy, the word heavy referring to the ease with which they are molded in agriculture.

Marls—Marls are mixtures of sands, clays, amorphous calcium carbonate and often potash or phosphates from the fauna and flora of the sea.

Humus—Humus is a term used to designate the product of vegetable decomposition in the various intermediate stages of the process. It is necessarily of very complex composition. Its principal characteristic is its high content of nitrogen.

Peat—Peat or muck contains a high amount of humus. Peat results from incomplete decay under water and is compact and fibrous. Inasmuch as the decay is incomplete, the peat varies in its compactness and fibrous character. It reduces to a powder when dry.

Constituents of the Soil—The chief constituent of the soil is silicon, the next is aluminum. The silicate of aluminum forms two-thirds of the earth's crust. Lime and magnesium are next in abundance. They occur chiefly as the carbonates. They are essential for plant life and hence to animal life. Lime exerts a marked influence in the conditions of the soil which favor the processes of nitrifica-

tion. Lime and magnesium also exist as phosphates and sulphates.

Iron is ubiquitous in the soil and important for all life. Manganese comes next in amount and is comparatively unimportant. Chlorin is not a large constituent of the soil. It occurs as the sodium, potassium, and magnesium salt. In unpolluted soil it is seldom present in quantities exceeding 1:10,000. Sulphur is most important to plant life. It occurs chiefly as sulphate or sulphide of calcium. Phosphorus is essential for plant growth. It is widely distributed in small amounts as phosphate of lime, magnesium, iron, and alumina, sodium and potassium, and chiefly as insoluble silicates and, in small amounts, as chlorids. Nitrogen exists in the soil in three forms, as follows:

1. Proteins.
2. Ammonia and its salts.
3. Nitric acid and nitrates.

In the average soils it is present in amounts of less than 1 per cent. In very rich soils it may be present in amounts of from 4 to 6 per cent. The nitrogen of the soils is not available for most plant life in any form, except the oxidized forms of ammonia, the nitrates.

The change of proteins and organic combinations of nitrogens to ammonia, and then into nitrates, is accomplished by various varieties of bacteria whose presence in the soil is really essential to plant life.

Porosity—Porosity is an important property of the soil. It is the sum total of the interstitial spaces of the soil. The amount of porosity of the soil depends not so much upon the size of the particles as upon their relative arrangement with each other. Even rocks have some porosity. Sand usually possesses 30 per cent and most soils at least 40 per cent.

Permeability in contrast to porosity depends upon the size of the individual spaces between the particles. The amount of moisture present in the soil greatly influences the permeability of the soil. It also depends upon the degree with which the soil is wetted from beneath the latter in contrast to wetting from the surface producing little effect on the permeability of the superficient layers. A freezing temperature also diminishes the permeability of water-laden soil.

The Capacity of Soil for Water—The capacity of soil for water

depends on a porosity of such a character that the size of the individual spaces is capable of exerting capillary attraction. A soil rich in organic matter possesses great power of holding water. Humus can hold 10 times its weight of water. Soils poor in clay and also poor in humus permit the passage of water in the shortest time. Clay and humus certainly contain water and the presence of much organic matter in the soil assists in the retention of water. The capillarity of the soil is very important for vegetable growth. At the same time it favors an increase of moisture in the air.

The Temperature of the Soil—The temperature of the soil depends chiefly upon the heat of the sun, and this in turn upon the obliquity of the sun's rays. Any heat derived from chemical changes in the soil is an unimportant quantity. The annual variation in the temperature of the soil diminishes as the distance from the surface of the ground increases. At a depth of 15 feet the annual variation in the temperature is less than 10° F., and between 50 and 80 feet the temperature is constant the year round.

A dark soil absorbs more heat than a white one which reflects it, although from the very fact that the white soil reflects it, it may feel hotter than the dark soil. There may be, for instance, an actual difference of 25° F. in the temperature of white sand and black humus exposed to the sun's rays, side by side.

Rocks, sand, and mineral matter are better heat conductors than water. Organic matter is a poor heat conductor. The specific heat of ordinary soils, i.e., the amount required to raise their temperature through 1° C., is 1/5 to ¼ of that of water.

The comparatively high specific heat of water causes it, therefore, to profoundly modify the temperature of the soil. Soil retains its heat in proportion to the amount of water which it contains, and loses it in proportion to the rapidity of evaporation, a process which in itself is accompanied at the expense of heat. The warm rain of Spring displaces the colder water of the soil and warms and preserves the heat of the soil.

Chemical Changes in the Soil and Mixing Forces—The chemical changes transpiring in the soil depend largely upon the bacterial life and proceed best at a temperature varying between 53° and 131° F. At 98° F. it proceeds most extensively near the surface and requires the presence of air. It practically ceases at a depth of more than 3 feet.

The various chemical changes in the soil and the properties of the soil are modified by the action of earth worms in the soil. These live on half-decayed leaves and vegetable matter. This they pull into their holes; it is eaten and passed out of their bodies again. They also excrete a humus acid which disintegrates rocks. They, therefore, play an important part in the disintegration of the soil, in the transporting and mixing of the nitrogen with the soil, and bringing to the surface the constituents of the deeper layers of the superficial soil.

The castings of earth worms contain .018 per cent of ammonia. It is estimated that 10 tons of earth pass through their bodies every year per acre. In the course of ten years their castings would form a layer .83 to 2.2 inches thick, according to the soil and the air circulating through the soil. The soil is much richer in carbon dioxid than the atmosphere.

The Carbon Dioxid of the Soil—The amount of carbon dioxid increases with the depth, up to certain limits.

The amounts at three different stations were as follows:

	1st station	2nd station	3rd station
1 meter deep	4.8	13.7	18.1
2 " "	6.6	14.3	28.4
3 " "	..	20.1	..
4 " "	28.7	..	36.5

The carbon dioxid is least in the cold months and greatest in warm months. The fluctuations depend upon the rainfall and the wind and the rise and fall of the water of the subsoil and the differences of the atmospheric pressure and the temperature.

The Air and the Soil—There is throughout the soil a constant circulation of the soil air. This depends upon the wind over the surface which aspirates the air beneath the surface of the soil, and upon the perflation of the soil by the wind, a force due to the direct impact of the wind upon the ground and particularly in uneven country.

Water in the Soil—Soil possesses different hydroscopic properties. The hydroscopic power of dust has already been mentioned. Soil rich in humus attracts and adheres to water very tenaciously. The dust, for instance, of country roads which is apparently dry may yield 1/10 of its weight in water.

The largest quantities of water are situated at a depth from the surface of the soil, but due to the power of capillary attraction there is a constant passage of the water upwards. The higher the temperature the greater the diminution in velocity and ease of movement from below upwards.

Dissolved substances influence the rate of this upward movement of water through the soil. The nitrates increase the movement and the chlorids and sulphate diminish it. The presence, however, of organic matter greatly diminishes the rate of movement of the water through the soil.

Due to the baking action of the sun, the capillary tubes in the surface of the ground become transformed into more or less permanent tubes, and the formation of such tubes greatly favors the evaporation of the water from the surface, and consequently the drying of the superficial layers of the soil. Any breaking up of the surface tubes, such as the harrowing of the earth, preserves the supply of ground water.

Ground Water—By gravitation all water falling upon the surface of the earth sinks through the earth at a rate depending upon the permeability of the soil, until it reaches an impermeable stratum. Over this stratum it collects, extending upwards until it fills all the pores between the grains of the soil for a distance which is proportionate to the quantity of water. This layer of water is called the subsoil or ground water and the zone between its upper level and the air-filled interstices of the soil is called the ground-water level. There may be a succession of the impermeable strata, each separating layers of water, which becomes ground water at some distant places where the two imprisoning layers approach the surface. Clay is positively impermeable to water, but may, nevertheless, transmit its water to a layer holding water and with which it is in immediate contact. Rocks differ much in their impermeability, some may contain as much as 1/3 of their weight in water. Rocks are also often fissured and seamed and thus through their crevices transmit water.

The ground water is in constant motion both laterally and vertically. The lateral movement depends much on the configuration of the land and the direction of the impenetrable stratum, the rainfall and the snow. It is generally in the direction of the nearest large body of water, either the sea, or a lake, or a river. In

Munich the rate is fifteen feet daily and at Berlin it is very slight. The principal source of the ground water is the rainfall, which most influences its rise and fall.

The Consumption of Ground Water—The loss of the soil water by evaporation is greatly increased by vegetation. Vast quantities of water are absorbed by the roots of plants and passed by capillary attraction to the leaves, from the surface of which by transpiration it passes into the air of the atmosphere. The oak evaporates more than 8 times the rainfall on the surface of the ground which it occupies. The roots of wheat penetrate 8 feet below the surface.

1	acre	of	wheat	exhales	409,832	lbs.	of	water	during	8	mos.
“	“	“	clover	“	1,096,234	“	“	“	“	“	“
“	“	“	sunflowers	“	12,585,994	“	“	“	“	“	“
“	“	“	cabbage	“	5,049,194	“	“	“	“	“	“
“	“	“	grapes	“	730,733	“	“	“	“	“	“
“	“	“	hops	“	4,445,021	“	“	“	“	“	“

Vegetation in the forests prevents the surface flow and increases the local retention of all the water of the rainfall and, although it exhales much water, it also prevents the waste of water. The growth in the forests also increases the penetrability of the soil for water. At least 4/5 of the rainfall is saved in the forests. The forests also prevent excessive changes of temperature which would otherwise increase the evaporation from the surface.

Pollution of the Soil—The soil becomes dangerous to the health when it becomes polluted by the discharges from human beings, or from the dead bodies of human beings or animals. There are many forces at work in the soil which will cause the disappearance of dead bodies, but much depends upon the nature of the soil. In the average soil bodies will disappear in a few years. In certain clays dead bodies will not disappear for two centuries. Bodies interred in loose, sandy, well drained, and ventilated soil rapidly become inoffensive. Those interred in compact and wet soil are slimy and very offensive and present a loathsome mass of rottenness.

The Purifying Forces in the Soil—The earth possesses great absorptive power for odors. This is illustrated by the absorption of gas from leaky gas mains. It exerts the same purifying action on substances in solution. From water it rapidly removes odors,

colors, and various other impurities. The finer the grain of the soil, the greater the purifying actions. The chief agent in the destruction of organic matter is bacterial action. There are few bacteria in the soil below a depth of 12 feet. Most of the bacteria are of the saprophytic varieties. Pathogenic bacteria are present as a consequence of the pollution of the soil by sick individuals who contribute specific organisms, or by the bodies of individuals who have died of specific diseases. Pathogenic bacteria so finding access to the soil do not find conditions favorable for a long-continued existence therein, although there is much variation among different species of bacteria in this particular. The majority of pathogenic bacteria cannot thrive in the presence of saprophytes. In the presence of the *bacillus cadaveris sporogenes* all pathogenic bacteria remaining in the dead body are destroyed. Two species of pathogenic bacteria are very widely found in the soil. They are the bacilli of tetanus and malignant edema. Both of these organisms, however, are spore-formers and, though widely distributed, even these do not find conditions in the soil favorable to growth.

The Relation of the Ground Water to the Preservation of Pathogenic Bacteria in the Soil—The height of the ground-water level, or in other words the amount of water in the soil, has much to do with the health of the locality. When the ground water is only 5 to 10 feet of the surface, conditions are far more healthy. It has always been found that ditching and the introduction of underground drainage have been followed by salubrity.

The Relation of Pollution of the Soil to Tuberculosis—A direct connection has always existed between the soil dampness and tuberculosis. The disease is comparatively rare in parts of the earth where the soil is dry. The explanation is, doubtless, not to be found in a single factor. Unquestionably a damp soil favors the preservation of bacilli in the dust and also has a direct bearing upon the excitation of the acute inflammations predisposing to pulmonary tuberculosis.

The Relation of the Dampness of the Soil to Typhoid Fever—Typhoid fever is very directly associated with the height of the ground water and the dampness of the soil. Typhoid bacilli implanted upon the surface of damp soil multiplied there and were found 130 days afterwards. Where they had been planted 18 inches below the surface they were actually found upon the sur-

face of the soil. Later in the winter they could not be recovered from inoculated areas, but in the Spring they were again recovered by moistening the earth with sterile broth. Typhoid bacilli will live for months when incompletely dried, but they will not stand complete drying for longer than fifteen days, although a few days' drying does not impair their vitality. The hydroscopic properties of dust already referred to are important in this connection.

The Relation of Virgin Soil to the Preservation of Pathogenic Bacteria in the Soil—Unpolluted virgin soil appears to possess properties which are inimical to typhoid fever, regardless of the amount of organic matter of vegetable origin, while specimens of soil containing organic matter of animal origin favors the preservation of typhoid bacilli. They appear to thrive equally well when kept at 37° F. as at 98° F. In one sterilized polluted soil, the organism was active after 456 days, even after thorough drying and pulverization.

In Munich at the time that the city was honeycombed with cesspools, typhoid fever was extensive and endemic throughout the city. When the cesspools became largely replaced with a sewerage system, there was an immediate drop in the frequency of typhoid fever, even though the water supply of the city was not changed.

The Relation of Specific Soil Bacteria to the Destruction of Pathogenic Bacteria in the Soil—Within certain soils, there are species of bacteria which destroy the typhoid bacilli. Implantation of these species with the typhoid bacilli result in the disappearance of the typhoid, though similar controls, the implantation of the typhoid bacilli with other species, produced no effect upon the vitality of the typhoid. In unsterilized soils containing bacteria inimical to typhoid, the vitality of the typhoid lasted only 12 days. Typhoid bacilli have been recovered after spreading the contents of a cesspool upon a clay soil into which the stools of a typhoid patient had been discharged five months previously. Even the exposure of the clay for 15 days during the winter had failed to destroy the bacilli. The evolution of heat due to the chemical changes in compost heaps exert a considerable effect on typhoid and cholera, destroying them generally within a week, though under the same conditions tubercle bacilli remained virulent for months.

There have been many places in towns and country districts, where typhoid has been unknown until the introduction of a single sporadic case, after which other cases developed from time to time. Moreover, in the country, where the inhabitants do not travel far from their own farms, single cases of typhoid fever will appear in the same household at intervals of a year or longer.

Cholera—Cholera is not a soil disease. In times of its greatest prevalence, it has never been found in the soil. Under favorable conditions it will live for short periods of time but under the natural conditions it dies out quickly.

Bubonic Plague—Bubonic plague is also not a soil disease. It appears to be entirely communicated by fleas, especially the common rat flea (*pulex pallidus cerato phyllus fasciatus*) to which mice, rats and other rodents, such as squirrels, may serve as common hosts.

Diphtheria—Statistics have not demonstrated with regularity that the prevalence of diphtheria is proportional to the dampness of the soil, nor that it is more common when the soil-water level is high. The greatest and most extensive epidemics have occurred when there have been four or five consecutive dry years. The epidemic started near the beginning or end of the period. Dampness of the atmosphere, associated as it is with dampness of the soil, predisposes individuals susceptible to diphtheria to throat inflammation, which makes them fit subjects to contract diphtheria.

There is no proof that diphtheria bacilli retain their vitality long in the soil. After intensive inoculation they have been recovered from the infected spots for short periods, but according to statistics they have never been found in soils other than those intentionally inoculated.

An epidemic of diphtheria never originates in the towns and countries following a series of years in which the rainfall is above the average, nor will an epidemic originate or continue through a wet year. All epidemics for which accurate statistics are available, have originated in dry years. The most severe epidemics were during four or five consecutive dry years, and in such cases near the beginning or end of such a series of years. Diphtheria, therefore, appears more closely related to a low level of the ground water.

Malaria and Yellow Fever—Malaria and yellow fever are en-

tirely dependent upon the existence of mosquitoes for their transfer to individuals. The presence of mosquitoes is favored by a heavy rainfall and the existence of stagnant or still-water pools. The existence of such pools, however, do not necessarily depend upon a high ground water level, although their frequency is dependent upon the same cause as a high ground-water level. The existence of such pools is a source of danger to the community and should not be permitted. Provision for their drainage has always been followed by a material reduction of the number of mosquitoes and constitutes the only efficient method of dealing with the mosquito evil. The covering of such pools with oil or the attempt to poison the larva of mosquitos is an entirely inadequate method.

Tetanus and Malignant Edema—Tetanus and malignant edema are essentially soil diseases as these organisms are so widely spread in the soil. Both organisms are spore-formers. Both, however, are anaërobes; this fact doubtless explains the reason that infection by either of these organisms is comparatively rare, when we think of the numerous soil-contaminated wounds. There always has been an outbreak of tetanus following Fourth of July injuries. This fact has given rise to the belief that blank cartridges contain the tetanus organism. Negative results have always followed examinations of blank cartridges made for the purpose of establishing the truth of this belief. In all probability the true explanation is to be found in the soil-contaminated hands or clothes and the lacerated character of the wounds of the victim of these infections.

Anthrax—Anthrax is a disease affecting cattle and sheep, and, in a less serious manner, man. Man almost always becomes infected as a result of his contact with infected animals or the hides of animals that have died of anthrax. For this reason the disease is called wool-sorter's disease.

Experiments with the cultures of anthrax show that these bacilli can be carried upwards on the stems of growing plants. It is probable that buried animals do not act as important foci of the infection. Earth worms have been blamed as transporters upwards of buried anthrax organisms, but it is not probable that they are such. Anthrax becomes distributed chiefly in the surface of the ground by the dejecta and secretions of infected animals.

Uncinariasis—Uncinariasis is the most important of all soil diseases and it is essentially a soil disease. The disease is caused by an intestinal parasite called the ankylostoma duodenale. This parasite is a worm ½ inch in length which attaches itself in great numbers to the villa of the upper intestine. It nourishes itself on the blood of its host. The eggs of the parasite are produced in enormous numbers and pass out with the feces. Deposited on moist soil they hatch in about 24 hours and the embryos, after twice shedding their skin, are ready in four to five weeks to infect man. They may enter the human being by the mouth in drinking water or upon green vegetables, etc., or they may attach themselves to the skin where they cause an intense itching and eruption, known as the ground itch, because it so frequently occurs upon the feet. The embryos make their way through the skin into the circulation and by the circulation into the intestines. The eggs will appear in the stools about 7 weeks after the worm has penetrated the skin. The embryos are not infrequently carried to the human beings in food by flies.

The ravages which the disease of unciniariasis has made in the Southern States are most serious. It has been stated that fully 90 per cent of the agricultural classes and the poor in general in the South are infected. The chief symptom of the disease is in an obstinate and not infrequently fatal form of anemia; and while the victim lives, all the evil train of symptoms of secondary anemia will appear.

WATER

Water is of supreme importance to the human race. It not only must be ingested in the alimentary canal in order to replenish the body fluids, but must be depended upon for cleaning purposes. It may truthfully be said that water forms the first necessity of life. Without drink man and animals would die more quickly than without food. A pure water supply is, therefore, of supreme importance.

Classification of Waters—Natural waters may be classified as:

1. Rain and snow.
2. Surface water (rivers, ponds, and basins).

3. Ground water (subsoil water).
4. Artesian water or deep well water.

Rain Water—Rain water always contains considerable of the gases of the atmosphere dissolved within it. These gases dissolve according to their coefficients of absorption. Rain also contains much of the dust of the atmosphere. After each rain the atmosphere is much clearer than before. It may be viewed as an efficient washer of the atmosphere. Much of the rain quickly flows off from the ground into the rivers. Fifty per cent of the annual rainfall in England is lost. The Rhine takes 50 per cent of the rainfall of the country which it drains, the Rhone 42 per cent, and the Seine 67 per cent. Rainwater usually contains 35 per cent of its absorbed gases as oxygen.

Surface Water (rivers and lakes)—This water varies much in its source and the character of the soil through which it passes and consequently its composition varies greatly. These waters are subject to many sources of contamination.

Ground Water—The manner in which this water is held and its varying upper level have already been described. The level of the ground water varies considerably; even in level country it does not necessarily correspond with the surface. In hilly country it may, in a rough way, correspond with the contour of the surface.

Ground water dissolves the soluble minerals with which it comes into contact in the soil and in its way through the surface layers. The ground water is in constant motion. This movement is generally in the direction of the nearest large body of water. The rate of this movement has already been discussed. It is controlled by many factors, the penetrability of the soil, the inclination of the strata, and the barometric pressure.

Oxygen in the Water—The amount of oxygen which is dissolved in water is important. At 15° C., 100 volumes of water will dissolve nearly 3 volumes of oxygen. At 20° C., it will dissolve 2.80 volumes of oxygen. Any addition of organic matter to the water greatly reduces its quantity of oxygen. There is a noticeable difference from this cause in the water flowing by or through a town above or below it. The pouring of organic matter into a river will diminish the oxygen sufficiently to kill the fish.

The dust falling into the water carries much oxygen with it and forms really a very important agent in the aeration of water. Aeration of water proceeds at great depths and upon this fact depends the ability of fish to live at great depths. In some waters oxygen may be absent at 40 to 50 feet deep. In many wells of depth, oxygen may be absent on account of the reducing effect of salts of iron and manganese which may be present. The presence of oxygen leads to beneficial changes in organic matter which may be present in the water. The absence of oxygen permits of the growth of certain forms of vegetable life which may impart a disagreeable taste or odor to water.

Carbon Dioxid in Water—Carbon dioxid is an important constituent of water. It increases its dissolving properties. It comes primarily from the atmosphere. It is present in large amounts in the ocean and particularly at great depths.

Organic Matter in Water—The amount of organic matter in water varies greatly and its amount and quality bear a very direct relation to health. Organic matter in water may be of animal or vegetable origin. That of animal origin is either sewage or the remains of animal life. That of vegetable origin exists as living and dead organisms and tissues in suspension, soluble and suspended substances given off during vegetable life, and soluble matters extracted by the water from dead vegetable material.

Microscopical Plants in Water—Many numerous species of microscopical plants are present in water. They act beneficently when not present in great numbers by absorbing the products of organic decomposition for their own life. By over-abundant growth they become troublesome. When they die, the products of their decomposition disappear rather slowly and are absorbed by new vegetable growths. When present in excess, these products cause foulness.

The crenothrix Kühniana is a filamentous plant occurring so frequently in waters that it deserves special mention. It grows extensively in ground water and fixes iron as a ferric salt in its gelatinous filaments. The iron so fixed gives the organism a brown stain and renders the water unfit for laundry work. This organism frequently occludes water pipes.

Ammonia in Water—The decomposition of organic matter in water leads to the development of ammonia and this may, therefore,

be taken as an index to the amount of organic matter present in water. The presence of ammonia is, therefore, of prime importance from a sanitary standpoint; because, where much contamination of water by organic matter has taken place, there is always the possibility of pollution by pathogenic bacteria and the presence of food for pathogenic bacteria to multiply upon.

Only under unusual conditions may ammonia exist as the hydrate in water. It usually exists as the chloride or the carbonate. Rain water always adds some ammonia directly to the surface waters. There is more ammonia in the rain of thickly populated districts. In surface waters ammonia is quickly transformed into nitrates. In this form it is rapidly appropriated by plants.

Albuminoid Ammonia—The so-called albuminoid ammonia is ammonia produced in the analysis of water by alkaline potassium permanganate on undecomposed nitrogenous matter. Such organic matter is decomposed with the formation of ammonia. Inasmuch, however, as it may come from animal organic matter and inasmuch as the latter resists natural decomposition longer than the former, the formation of albuminoid ammonia is not of much importance unless we know the nature of the organic matter giving rise to it.

Nitrites and Nitrates—By the nitrifying bacteria the ammonia formed by decomposing organic matter is oxidized to nitrates through the intermediate stage of nitrites. Such oxidization occurs to a much greater extent in the soil water. The nitrite or nitrous acid stage is extremely short. Nitrates are seldom absent and they may be present in as large amounts as 6 or 7 parts per 100,000. While in unpolluted water nitrates are not ordinarily present in as high percentage as one part to 100,000.

Certain anaërobic bacteria known as denitrifying bacteria possess the power in the absence of oxygen of changing the nitrates back to nitrites and ammonia. These species are doubtless numerous, though few forms have been isolated. Because of the absence of oxygen in sewage these species are apt to be present in it. Small amounts of nitrites may also be derived from air due to the contact of the nitrates with metallic or brick surfaces, but they are very seldom present in greater proportions than 1:100,000,000, or over, except as a result of sewage pollution.

Chlorids—Chlorin as sodium chlorid is present in all waters.

It is washed down from the atmosphere, particularly near the coast. Whenever there is distinct increase of the chlorids in water it means pollution. The amount of chlorids varies proportionately with the population of the area drained by the water in question. In specimens of rain water, chlorids are present up to .13 per 100,000. Twenty persons per square mile add on an average of .01 parts per 100,000 to the water of a district in seasons of average flow.

Mineral Matter—The mineral matter dissolved in water depends much upon the character of the ground through which the water flows. Silicate of aluminum is least acted upon and is soluble to the extent of 1:200,000. Silicious rocks in general are attacked only slightly. Limestone, lime, and magnesium carbonates are dissolved with comparative ease. Gypsum is also easily dissolved.

Special waters represented by many natural springs bring much mineral matter to the surface. Iron in traces is present in most waters. One-fourth of a gram per gallon imparts a definite chalybeate taste. Altogether, 50 parts of mineral matter per 100,000 are excessive.

Hardness—Hardness is the capacity of water for dissolving soap. It depends upon the amount of magnesium and calcium in solution. One grain of chalk will form a new combination with the fatty acids of 8 grains of soap before any lather is produced.

Water containing considerable carbon dioxid holds in solution more calcium and magnesium carbonates which may be precipitated by boiling. The water then is not so hard. Such hardness is known as temporary hardness. The chlorid and sulphate of calcium are not affected by boiling. Magnesium carbonate redissolves in cooling water. Permanent hardness, therefore, is due to calcium sulphate and chlorid and to magnesium carbonate; 5 parts of all these salts per 100,000 is regarded as excessive. Calcium sulphate will form a scale in boilers. It is less soluble in hot than in cold water. It forms a very hard scale, while the scale, due to calcium or magnesium carbonate, or temporary hardness is easily removed. A peculiarly hard scale is formed by a combination of parts of lime and magnesium (2.30) in combination with rather large amounts of silica (2.60).

Hardness is not only economically objectionable but it makes vegetables harder in the cooking and more indigestible.

Bacteria in Water—There are some known varieties of bacteria which may be regarded as normal and harmless inhabitants of the water. They are all saprophytic and fulfil useful and nitrifying functions. In addition to saprophytes there may be present pathogenic bacteria or at least bacteria whose natural habitat is man and animals.

Saprophytic Bacteria—Saprophytic bacteria may be present in large quantities in water containing no organic matter. In relatively pure water their multiplication is more rapid than in water containing much organic matter, though in the latter their growth is persistent. They are much more abundant in surface waters. Different varieties are present in unpolluted ground waters. In these, there is an abundance of the liquefying chromogenetic varieties. These characters are sufficiently marked to afford a basis of ascertaining whether ground water, when brought to the surface, has been contaminated or not. Ground water when brought to the surface soon becomes rich in the forms of bacteria usually present in surface water.

There are many causes for variation in the bacterial content of surface water. Sedimentation of matter contained in the surface water carries down the bacteria entangled in such matter. Sunlight and the growth of algæ by consuming the food of the bacteria are important causes of diminution of the bacteria. The bacteria increase in surface water during the winter months and this is probably due to the influx of more nutritive matter.

The Vitality of Pathogenic Bacteria in Natural Waters—Pathogenic bacteria probably do not increase in water whether or not there is an abundance of nutriment. They live for a certain length of time with undiminished virulence and then become altered in this respect and tend to disappear.

Cholera—Cholera bacilli have been found in the Seine water in an active state for seven days' time and in ordinary drinking water for twenty days.

Typhoid—Typhoid bacilli live for various periods according to circumstances. It has been found in very pure water after more than seven weeks. In badly polluted water its life is very short. Sunshine and temperature profoundly affect it. The rays of the sun will kill typhoid bacilli to a depth of 5 feet in 4½ hours, though at double this depth the effect of sunlight is hardly perceptible.

Typhoid organism survives longer in cold than in warm weather, though the reason is probably because of secondary considerations.

Anthrax Spores—Anthrax spores become much diminished in numbers or actually destroyed in a short time in unsterilized water but in sterilized water their virulence remained undiminished for 7 months or more.

Saprophytic Bacteria Specifically Harmful to Pathogenic Organisms—It is to be assumed that the substances excreted by the saprophytic bacteria which are toxic to pathogenic bacteria are not excreted by all saprophytes and that the bacteria specifically inimical to pathogenic bacteria may not be present in all surface waters or ground waters.

Colon Bacilli and its Significance—The presence of the colon bacilli is the most significant guide to sewage pollution. It is true that this organism is sometimes found where its presence cannot be traced to sewage, but, nevertheless, its presence in a majority of 1-cubic-centimeter samples, is a safe guide to pollution of water by sewage.

Water Supplies—Water may be supplied for use by man in the following varieties:

1. Stored Rain Water.
2. Rivers, Lakes and Gathering Basins.
3. Ground Waters, including Wells and Filter Galleries.
4. Springs.

Stored Rain—A house of 40 ft. square having a surface area of 1,600 sq. ft. and a rainfall of 1″ will furnish 997 gallons and at an average rainfall of 43.17 inches a year, it will provide 43,000 gallons a year, or 120 gallons a day.

Automatic devices have been invented for diverting the first fall of water containing the dust and dirt which has collected on the roof. Such cisterns should be protected from contamination by mice or insects and from the sun in order to prevent the growth of algæ.

Surface Water—Surface water is derived from rivers, lakes and artificial lakes. These sources are very liable to contamination. One town, or community, or even a single house frequently furnishes contamination to those situated further down. These waters should be well exposed to sunlight and in the case of artificial lakes the surface layer with its contained organic matter should

be removed at the time the lake is made. When these waters are used for drinking purposes they should be frequently tested and too great care cannot be exercised in preserving them from any contamination by the products of animal life (Fig. 6).

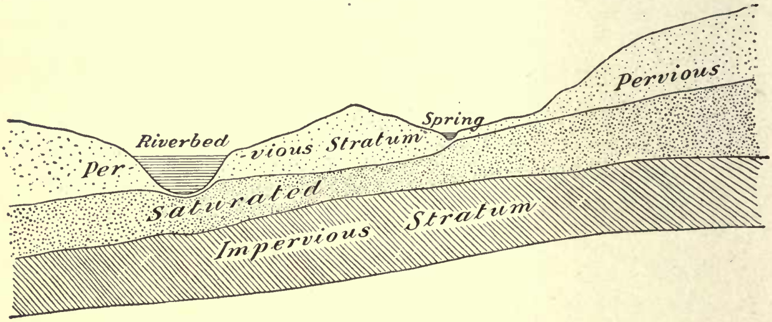


Fig. 6. Outcropping of water table. (Harrington.)

Ground Water—In general this water is purer and preferable to surface water, provided it is not too hard.

Springs—These are the local outcroppings of the underground water table. They are subject to much variation in flow and are by no means immune from contamination by any source of surface contamination so placed in relation to the underlying strata, that drainage in the direction of the spring is favored.

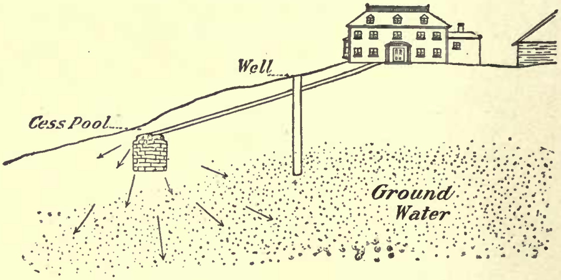


Fig. 7. How a well located on high ground may be polluted by the contents of a cesspool lower down. (Harrington.)

Wells—Wells may be dug, driven or bored. The only important classification of wells from a sanitary standpoint depends upon the relation of the well to the underlying impervious strata. All wells above this, whatever their depth, are to be regarded as col-

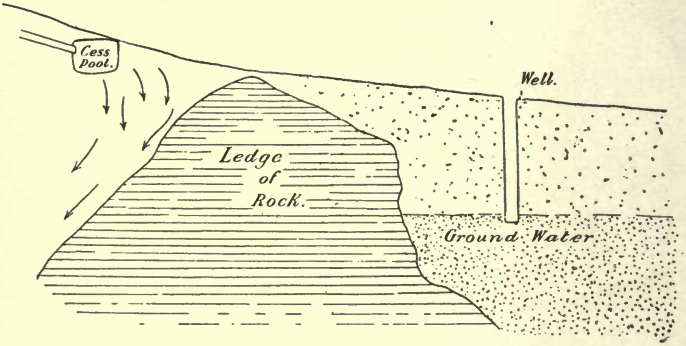


Fig. 8. How a cesspool located on high ground may fail to pollute a well lower down. (Harrington.)

lecting places for ground water and, therefore, for the surface contamination of all the surrounding country so placed in relation to the inclination of the underlying impervious strata, that drain-

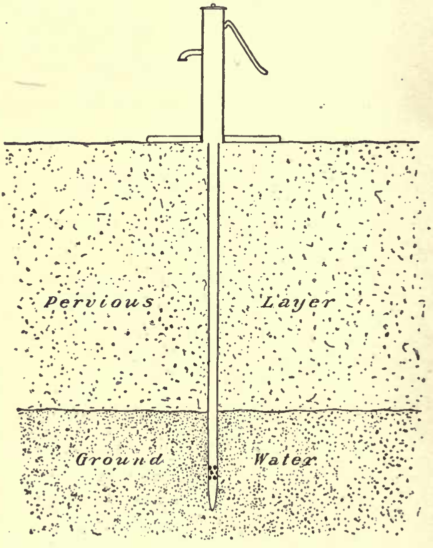


Fig. 9. Norton tube well. (Harrington.)

age toward the well is favored (Figs. 7 and 8). Without control of the surface on the high side of the underlying impervious strata, wells are unsafe. This of course necessitates a knowledge of the

inclination of the underlying impervious strata, which by no means always corresponds to the surface contour.

All wells should be completely closed at the surface in order to prevent the entrance of live things. Their walls should be cemented for a considerable distance below the surface.

Driven Wells are made by driving a pipe 1¼ to 4 inches in diameter into the ground until water is reached. One length of pipe is screwed to another as the pipe is sunk (Fig. 9).

Bored Wells—Bored wells are made practically in the same manner but are much deeper and must be drilled through solid rock and are lined with iron pipe backed with cement as the case may be. Their cost is much greater but they extend through the impervious strata beneath and are many hundred feet in depth (Fig. 10).

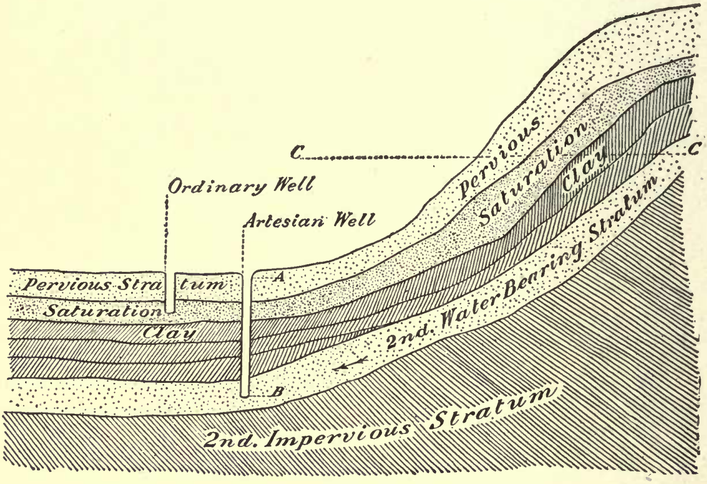


Fig. 10. Geological formation favorable to the obtaining of water by means of artesian wells. (Harrington.)

These wells possess the advantage of not being contaminated by surface water. Such wells should always be deep, so as not to require forcing, as in this case their bottom forms basin centers toward which water from all directions gravitates in a manner to bring water down from the upper strata and at such a rate as to preclude the purification normally carried on by the saprophytes. The water from these wells usually contains much inorganic matter and is generally warmer than the surface or ground

water on account of the increase of 1° F. for every 55 feet of distance from the surface. Distinctly hot water occasionally met with is unfit for domestic purposes on account of its great solvent power.

One has no means of knowing how far the water from these deep wells has traveled.

Purification of Water—There are several natural methods by which water is purified.

The Soil—The soil has enormous power of purifying water. It accomplishes this purification (1) by mechanical retention, (2) by oxidatic processes of both a chemical and vital nature, and (3) by the saprophytic bacteria within it. All soils, however, do not possess this purifying power to an equal degree. The soils most favorable to the purification of water are sandy or gravelly soils. In these the water is exposed in layers to the air in the interstices between the grains. These grains should neither be too coarse nor too fine.

Importance of Ascertaining the Direction of Flow of Ground Water—Much also depends upon the direction of the flow of the ground water. This direction may be determined by fluorescein. An ounce of this substance will impart a very decided color to an enormous volume of water and can be detected in the direction of the flow sometimes for hundreds of feet.

Efficiency of Natural Purifying Agencies in Surface Water—In surface waters themselves there are a number of purifying agencies. It is in virtue of these forces that the river Isar, two hours after flowing through Munich, becomes as pure chemically as before it entered the city. After 34 miles' flow, the Illinois River is practically free from sewage. The same is true of the Seine and other rivers in England and Germany. There is much difference in the efficiency and number of these purifying agencies of different surface waters.

Oxidation as an Agency for Purifying Surface Water—Oxidation water containing sewage would lose ½ its organic matter when made to run 1 mile through glass tubes with abundant aeration. The nature of these oxidative processes are not thoroughly understood, as agitation alone with air does not produce the expected diminution of contained organic matter.

Dilution as Agency for Purifying Surface Water—Dilution,

while it may diminish the relative proportion of the organic matter, may increase the bacterial content, a factor which is not necessarily an unfavorable one, as the increased varieties may be the saprophytic bacteria, which may still further destroy the organic matter.

Sedimentation as Agency for Purifying Water—Sedimentation is only efficient in very slowly flowing rivers and in lakes. When it occurs, it markedly diminishes the number of bacteria, especially in muddy water.

Bacterial Action as an Agency for Purifying Water—Bacterial action favored by alkalinity may or may not be important, according to conditions. Destruction of pathogenic bacteria by the saprophytic varieties is delayed by dilution and by unpolluted water, which, as above stated, favors their increase for a short time, after which they rapidly decline.

Vegetation as an Agency for the Purifying of Water—The various varieties of vegetable algæ take up all manner of organic substances, including even volatile fatty acids, amino acids, glucose, and urea. Thus they rapidly diminish the food available for the bacteria and may be considered as purifying agents second to none in importance.

Temperature as a Purifying Agent of Water—It has been found that the colon and typhoid bacilli disappear from the natural waters more rapidly in the summer than in the winter time. This is due to the fact that the warm temperature in the summer time is favorable to the growth of algæ and other microscopic plants which do not grow at 0° C.

Artificial Methods of Purification of Surface Water—The artificial methods of purification of surface water are chemical treatment, boiling and distillation, and filtration.

Chemical Treatment—For this purpose chemical substances are employed to cause the formation of insoluble precipitates which settle out and entangle suspended matters, including bacteria, in their descent.

Alum—Alum added to the extent of ¼ grain to a gallon of natural water, which contains a moderate amount of calcium carbonate, is decomposed and forms an insoluble gelatinous hydrate, which combines with the organic matter present, imparting a color and settling out as a flocculent precipitate. As an accessory

change during the decomposition of the alum, sulphuric acid is set free which unites with the lime or other bases present. The calcium sulphate thus formed is insoluble and also settles out, thus further purifying the water. When calcium carbonate is deficient, limewater may be added and the same result obtained. If it is desired to avoid the formation of sulphuric acid, the addition of freshly precipitated aluminæ serves equally well.

If carbon dioxid is present in the water, the addition of limewater alone will cause an efficient precipitate by uniting with the carbon dioxid and forming calcium carbonate. Moreover, the removal of the carbon dioxid causes a precipitation of the natural calcium carbonate which was held in solution by the carbon dioxid.

Potassium Permanganate—Potassium permanganate has been used. Enough should be added to give a slight color for 24 hours, but little can be said in its favor.

Hydrochlorites—Hydrochlorites are also oxidizing agents and act much like potassium permanganate. Neither of them retain their identity for any length of time in water. When a bleach (a double salt of calcium hypochlorite and calcium chlorid) is used in combination with alum as an adjunct to mechanical filtration, a more satisfactory removal of the bacteria and a less expensive one is obtained than when sulphate of alum is used alone. In such a process, disinfection occurs in the coagulation basin before the water reaches the filter and the subsequent filtration adds another factor of safety. Experiments show that 0.9 grains of sulphate of alumina and 0.7 grains of soda per gallon, in combination with bleaching powder, are equivalent to 0.11 parts of available chlorine per 100,000, and give the best results.

The use of hypochlorites cannot be considered as a substitute for filtration of water, but as an adjunct it has a distinct field of usefulness. It makes possible, moreover, higher rates of filtration and it thus becomes an economy. Its use results substantially in the destruction of objectionable bacteria, particularly those of intestinal origin.

There is a total absence of poisonous features in the end products. The use of hypochlorites permits of high rates of filtration when the bacterial content is high. The speed of the reaction is immediate and the cost is nominal. It does not destroy spore-formers nor does it remove turbidity or appreciable amounts of

color, dissolved vegetable stains or organic matter. It does not soften water but rather slightly increases its hardness. There are, moreover, difficulties of applying the method, except with the greatest care, to waters which contain substantial quantities of reducing agents, or compounds capable of oxidation such as nitrates and unoxidized iron. If, however, used in connection with filtration, none of these objections are very serious.

Bromin, Ozone, Bisulphates, and Copper—The use of bromin, ozone, sodium bisulphate, and copper sulphates are to be mentioned only to be condemned. Copper sulphate, 1 part to 4 to 5 millions, destroys with the bacteria and the algæ which are valuable agents working toward the same end as the disinfectants.

Ultraviolet Light—The ultraviolet light has been suggested. Applied efficiently it produces an extensive destruction of bacteria and practically a complete sterilization of clear water; but as a practical method of disinfection of public water supplies, it is hardly feasible.

Boiling—For domestic use, boiling the water is a convenient and reliable means of rendering it pure. The flat taste may again be restored by aeration. This can be simply done by pouring it from one vessel to another. It should always be practised when suspicious water must be depended upon.

Filtration—The only domestic filter of any use is the Chamberland Pasteur filter (Fig. 11) and the Berkefeld filter. The Pasteur filter is made of well-baked kaolin of the proper degree of porosity and hardness. The Berkefeld filters are more porous. They are now made of a special blend of clays used in the manufacture of the finest porcelain.

Bacteria will grow through these filters. It has been repeatedly proved that normal water and water artificially infected will yield on the first day a perfectly sterile filtrate and on the second or third day a very small number of bacteria will be present in the filtrate but these are the ordinary water bacteria. The pathogenic varieties appear considerably later. The shortest time in which the typhoid bacillus has passed has been 4 days. In order to keep these filters safe it is necessary to scrub them and boil them twice a week.

Filtration of the public water supply of towns and cities on a large scale, by passing the water through sand and gravel arranged

in layers composed of pebbles and grains of proper size, has proved to be an important and efficient method of purifying water. They

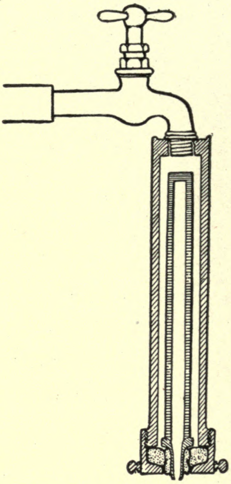


Fig. 11. Chamberland-Pasteur filter. (Harrington.)

consist of immense tanks of concrete (Fig. 12). Upon the paved bottom is laid a system of perforated or disjointed pipes. Above these are successive layers of coarse gravel, fine gravel, coarse sand

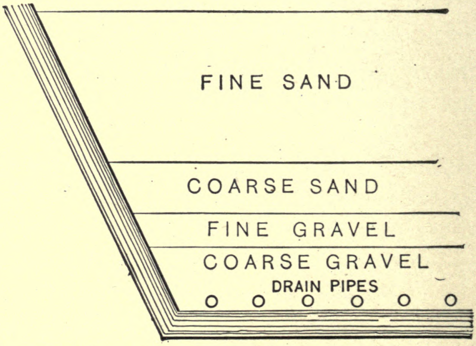


Fig. 12. Partial vertical section of one form of filter bed. (Harrington.)

and fine sand, the latter being 3 to 5 feet in depth. The fine sand is sharp-grained in character, though the sand of the seashore may be used. It should not contain clay. The size of the sand particles

should be 1/5 to 1 mm. in diameter and possess the volume of a grain.

Before the water is allowed to flow upon the filter, if it comes from a turbid river, it is advisable to let it stand several days in a settling bed or basin. The suspended matter is thus loosened in amount and the organic content diminished or destroyed by bacterial action. The bacteria themselves finally become diminished in virtue of being carried down by the material settling out and by the death of the less resistant varieties.

The water is delivered continuously at the surface of the filter by automatically regulated devices. The first water coming through the filter is not much better than the affluent, but there soon forms around each grain of sand at the surface a gelatinous growth of algæ, which entangles the suspended matter. This superficial layer removes mechanically the solid material and bacteria in the water. By means of the water-bacteria which accumulate in the filter, the organic matter and finally the bacteria themselves, at least the less resistant forms, are destroyed.

All organic matter is not acted upon to the same extent during filtration. Some is decomposed very rapidly and mineralized, while other matter is acted upon so slowly that complete removal during passage through the filter is impossible. This latter class of organic matter includes the brown coloring matter of vegetable origin, so common in surface water. It forms a very stable compound and nitrifies slowly. By the alum process of coagulation, it is coagulated and quickly removed.

The efficiency of the filter as a whole is demonstrated by the fact that the sluice layer at the surface may be stopped off without changing the bacterial count of the effluent. Unquestionably the most of the filtration is done in the upper layers of the filter. The active agents in bringing about the death of the bacteria contained in the effluent and in accomplishing the destruction and mineralization of the organic matter, belong to the same class of nitrifying organisms which are commonly at work in the soil.

It is important that the filtration should be uniform over the whole filter. It has been proved by the Board of Health of the State of Massachusetts, that 2,000,000 gallons can be filtered through 1 acre of filter bed per day with the removal of substantially all the bacteria present.

The downward movement should not exceed 100 mm. per hour. The filtrate of each section should be examined daily while the bed is at work and a filtrate containing more than 100 bacteria to the cubic centimeter should be rejected.

When the filter begins to filter slowly it is not safe to increase the pressure. Such a procedure has been accompanied with an outcrop of typhoid.

When the filter shows signs of clogging, an inch or two may be scraped off from the top of the filter and the filtration proceeded with anew. Successive cleanings may take place without replacing the sand until the depth of the filtering material is reduced to 15 inches. The scraped-off sand may be washed in a special machine until it shows no turbidity and stored for later use in the filter. Sterilizing the sand is harmful because it kills the saprophytes.

In winter the filter beds should be covered in order to prevent freezing, which is responsible for imperfect and uneven filtering. The removal of ice is expensive and injures the surface layer of the filter. It is also an advantage to cover the filter beds in summer, as by so doing the growth of algæ is prevented. This reduces the necessity of so frequently cleaning the filter.

It is an advantage to give the filter a rest for a part of each day, as by so doing the interstices of the filter become filled with air, which is an important factor in the completeness with which the process of nitrification will be accomplished.

Intermittent filtration makes necessary, of course, an increase in the area of filter bed.

By mechanical filtration, a form of filtration used in a number of places in the United States, is meant the passage of water under pressure, at a comparatively fast rate of speed through coarse sand or crushed quartz contained in an iron or wooden cylinder.

Alum is used as a coagulant and thus an artificial film is produced. It is called mechanical only because of the power needed to force the water through, and the raking and shaking in the process of cleaning, which must be done at comparatively short intervals. This method of filtration replaces entirely the top slimy layers.

Mechanical filtration is particularly valuable for the highly

colored and turbid waters of the West. With careful manipulation it may remove 99 per cent of the bacteria.

The Removal of Hardness—Temporary hardness may be removed by boiling, which is too costly a method for use on public waters, or by the use of limewater. Limewater does not affect the sulphates and chlorids. For the removal of permanent hardness, caustic soda or sodium carbonate may be used. The removal, however, of the temporary hardness is as a rule quite sufficient and involves a considerable saving of expense and labor in washing. In Southampton, England, 2,000,000 gallons of water are treated daily with limewater at an almost insignificant cost.

Contamination of Water by Poisonous Metals—Water takes up an appreciable quantity of iron from iron pipes and zinc from galvanized iron pipes and lead from lead pipes. Probably chemically pure water would not do so, but no actual waters are free from carbon dioxid and oxygen, which increase its solvent action on metals.

Where lead pipes have been in use, numerous instances are on record of chronic and even fatal cases of lead poisoning from this cause. At Summerfield, where a number of cases occurred in 1888, 6 milligrams per liter were found.

Sulphuric acid is not infrequently in water and the so-called peaty acids. Acids developed in water coming from peat deposits possess the power of dissolving lead. Peaty water comparatively poor in carbon dioxid can take up 300 parts of lead per 100,000 over night.

Ammonium compounds and nitrates in water exposed to the air have a solvent action on lead. A certain protection is afforded to older lead pipes by certain waters on account of the formation of an insoluble coating formed from the chlorids, carbonates and silicates. Sodium and calcium carbonate are very efficient in this particular; bicarbonate of sodium, so generally present in soft waters, is less so. Calcium carbonate is efficient whether carbon dioxid is present or not. Four grains to the gallon are quite sufficient to afford protection.

The use of galvanized iron pipes is no protection against the corroding effect of the water on the pipes and the solution of the zinc of the coating of the pipes. The lining is easily corroded, if the water contains oxygen, carbon dioxid and ammonia or nitrates,

so that the water is actually made milky by the oxid and carbonate in suspension as a result of this action. The zinc compounds are not especially toxic but they are capable of causing constipation. Occasionally gastro-intestinal pain, diarrhea, and consequent anemia, and emaciation and a spurious kind of dysentery, have resulted where considerable amounts of zinc have been dissolved. As much as 5 grains per gallon have been found in some natural waters (Tutendorf). No unpleasant effects were noticed by those who used the waters.

WATER AND DISEASE

There are three main water diseases, (1) Typhoid, (2) Cholera, and (3) Dysentery.

The Danger of Water Contamination by the Bacillus Typhosus—The strongest proof of the relation of the water supply to typhoid fever is the immediate drop in the mortality from this disease whenever a city in which the disease had been frequent has adopted purified water. Lawrence, Mass., prior to 1893 used unfiltered water from the Merrimac River, which was polluted by several towns above Lawrence. The following figures give the death-rate per 10,000 of the population before and after the installation of a public filter in 1893:

Preceding the use of Filtered Water—

1889	12.7
1890	13.4
1891	11.9
1892	10.5
1893	8.0

After the use of Filtered Water—

1894	4.7
1895	3.1
1896	1.9
1897	1.6

The city of Hamburg adopted filtration in 1893 after a most devastating epidemic of cholera. The typhoid death-rate had

always been high. From 1890-93 the death-rate was 2.6 per 10,000. During the year 1894-95 it fell to 0.75.

In Philadelphia during the first six months of 1899, there were 7,035 cases of typhoid with 800 deaths in a population of over 1,000,000. Between January 1st and April 11th, 1904, in a population of 1,300,000 there occurred nearly 2,500 cases and of these no fewer than 389 were reported in a single week. In that part of the city, however, in which the new supply of filtered water was used there was an immediate drop in the typhoid rate.

Methods of Contamination of Water by Typhoid Bacillus—Typhoid contamination of water may be direct when sewage containing the bacilli flows directly into the water or indirectly when the bacilli in feces and urine are washed by the rain into the water courses. The harmful possibilities of the pollution of water by the discharges from typhoid individuals depend upon the period during which the feces and urine of infected individuals contain bacilli, and the length of life of the bacilli after discharge from these individuals. The bacilli as a rule exist in the feces of sick individuals only during the early stages of the disease and up to the 20th day, though the intestinal mucous membrane may in some individuals give them up for very long periods. The urine has been found to contain many millions of the bacilli in each cubic centimeter and they may be contained in the urine for many weeks even after convalescence is well established. An apparently well person may be capable of giving off bacilli for long periods.

In the water courses the tenure of life of the typhoid bacillus is not a long one and due to the dilution of the water the bacilli may never reach many individuals drinking the water.

Because of these considerations, the highest death-rate from typhoid fever is not in the large cities but in towns which have no public water supplies. In other words special and small water supplies, contaminated in a manner to produce a special concentration of the bacilli, are far more dangerous. Nevertheless, the public water supplies are a very real source of danger and the diminution of the death-rate from typhoid fever by special provisions for the purity of the water supplies fully justifies such precautions.

The Danger from the Water Infected by Cholera Bacilli—

Cholera, even more than typhoid, is a water-borne disease. Where no special measures are taken to guard against the use of impure water, its ravages are very horrifying. In India the disease is endemic and from there it makes periodic excursions into the rest of the world.

In one of these excursions, in 1892, from the valley of the Ganges through Persia, the disease claimed 20,000 victims in Teheran alone, and in its course through Russia killed 215,157 more persons. Regarding the danger from polluted water supply no more speaking example could be furnished than the experience of Wandsbeck, Altona and Hamburg. Wandsbeck was supplied with filtered water from a lake but little subject to pollution. Altona was supplied by filtered water from the Elbe drawing the water below Hamburg and, therefore, from water contaminated by the sewage of Hamburg (Fig. 13). Hamburg drew its water from the Elbe, but inasmuch as it was situated above Altona on the river it did not filter its water. During the epidemic above referred to, in the summer of 1892 (between August 17 and October 23), Hamburg, with a population of 640,000, had nearly 17,000 cases of cholera, of which more than 50 per cent died. Altona, ¼ the size of Hamburg, had only 500 cases, 400 of which came over from Hamburg. In the first week of December and again at intervals

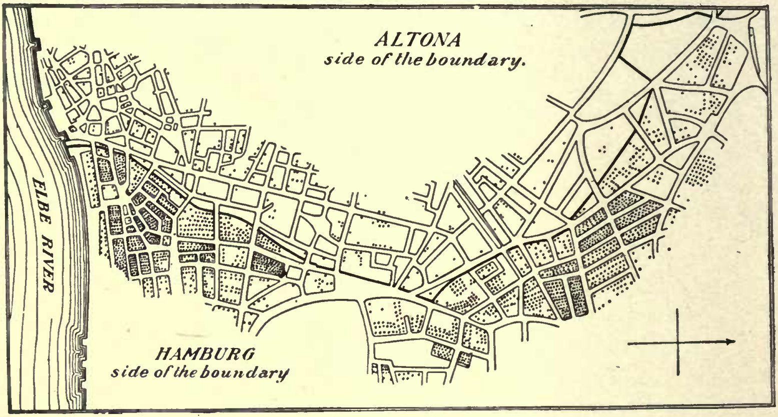


Fig. 13. Portion of the boundary line between Hamburg and Altona. The dots indicate cases of cholera. (Harrington.)

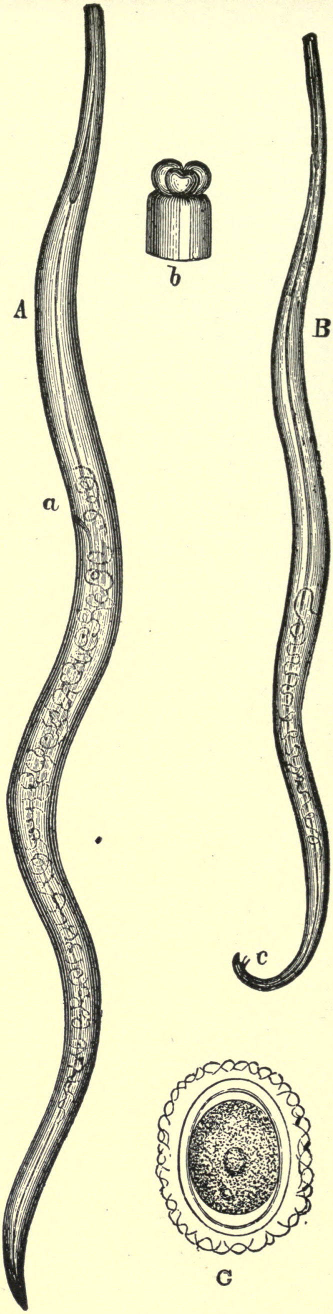


Fig. 14. Ascaris lumbricoides: A, female; B, male; C, egg. At a, the female genital opening; b, the enlarged cephalic extremity, with its three lips; c, the male spicules. (Simon.)

in January there was an increase in the number of cases in Altona. Investigation showed that at these times the filter was not working perfectly because of freezing during the cold weather.

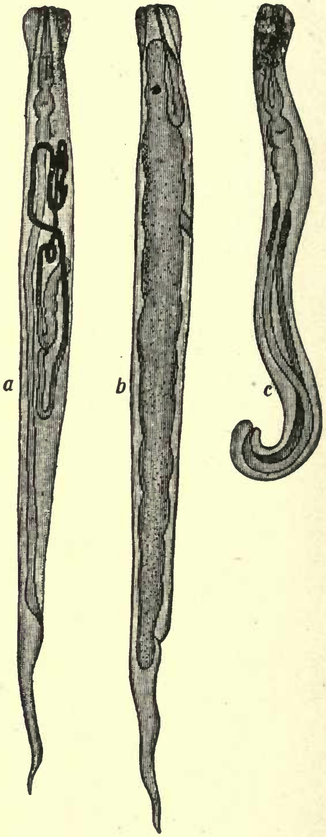


Fig. 15. Oxyuris vermicularis: a, sexually mature female; b, female filled with eggs; c, male. Magnified, 10. (Simon.)

The home of cholera is India and will unquestionably continue to be so long as the filthy habits in attending to the calls of nature and disposing of the dead continue. The evils are aggravated by the crowding at the religious festivals of the country.

Parasitic Diseases Conveyed by Water—Besides these bacterial diseases, water is responsible for a number of diseases which are due to vermiform parasites.

Round Worms, Ascaris Lumbricoides (Fig. 14)—Round worms, *ascaris lumbricoides,* are probably spread by drinking water. The female yields numerous eggs which pass out with the feces and may require another host for their full development.

Pin Worms, Oxyuris Vermicularis—Pin worms also are probably spread by drinking water. They inhabit the cecum and upper colon and yield an enormous number of eggs (Figs. 15 and 16).

Guinea Worms, Dracunculus Medinensis—Guinea worms are believed to invade the body through the skin of bathers or through the stomach when ingested in drinking water. The gastric route has been proved. In the stomach the embryos become rapidly mature and the impregnated female proceeds to the subcutaneous tissues of all parts of the body through which she finally breaks and escapes. The liberated embryos finding themselves in fresh water enter the bodies of the common fresh water flea which acts as the intermediate host. These worms are of unbelievable length when they are in the subcutaneous tissues, often 25 inches.

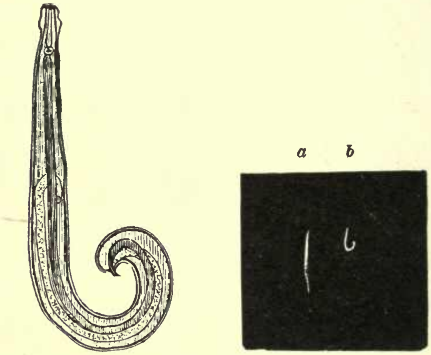


Fig. 16. Oxyuris vermicularis: a, male; b, female; natural size. Magnified, 2. (Simon.)

Thread or Whip Worm, Trichocephalus Dispar—The thread or whip worm is an intestinal worm about 2 inches in length. The front part of the body is hair-like in slimness. It enters the body probably in drinking water.

Filaria Sanguinis-hominis—This worm enters the body from drinking water. The adult enters the thoracic duct or large lymphatic trunk and produces countless embryos which invade the

blood stream during sleeping hours (Fig. 17). Mosquitoes then suck the blood of the afflicted individual and act as intermediate hosts. By the mosquitoes the embryos are transferred to drinking water.

Bilharzia Hematobia—This worm inhabits the pelvis of the kidney and causes a peculiar hematuria and often stone. It is believed to enter polluted water from the urine of infected individuals.

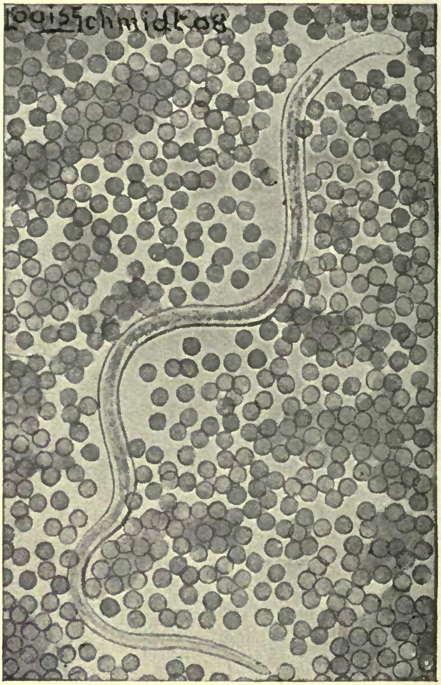


Fig. 17. Microfilaria nocturna. (Wilson.)

Ankylostomum Duodenale (Figs. 18, 19, and 20)—This worm has already been mentioned. It is probable that the chief source of infection is the soil.

Strongyloides Intestinalis—The parasite of an endemic diarrhea of China is strongyloides intestinalis. The embryos occur in the stools and are transferred by drinking water.

The Danger of Bacterial Infection from Ice—Ice is seldom a

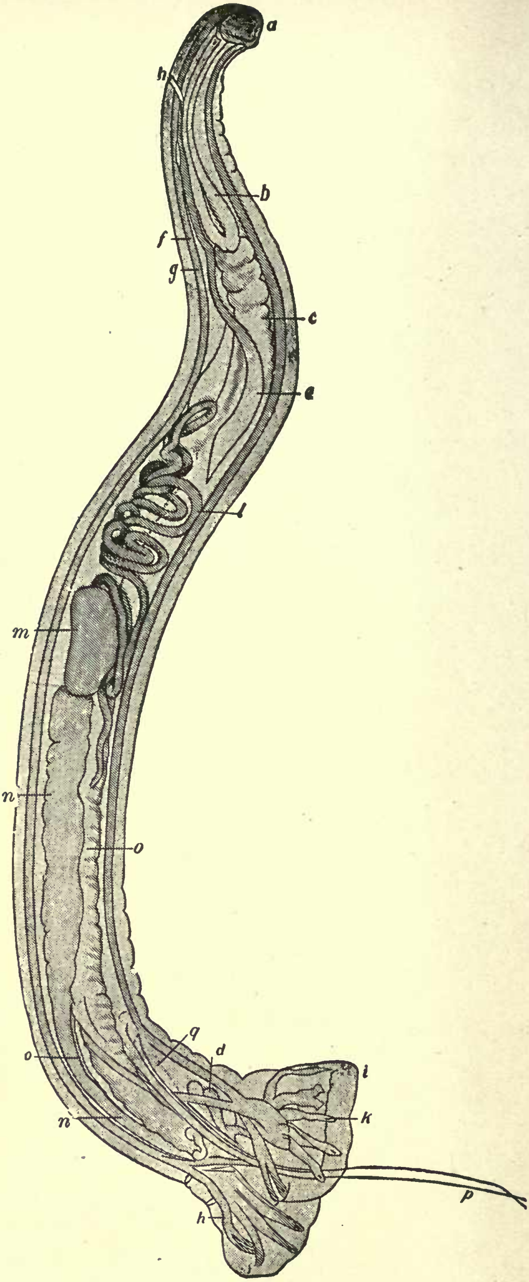


Fig. 18. Male ankylostoma duodenale: a, head; b, esophagus; c, gut; d, anal glands; e, cervical glands; f, skin; g, muscular layer; h, excretory pore; i, trilobed bursa; l, seminal duct; m, vesicula seminalis; n, ductus ejaculatorius; o, its groove; p, penis; q, penile sheath. Magnified, 20. (Simon.)

source of danger of bacterial diseases. Most of the bacteria are eliminated by the process of freezing, as has been proved, experimentally using the colon bacillus in polluted water as a test. Occasionally in exceptional circumstances, particularly where rapid freezing has taken place and actual sediment is included in the ice, the ice may be a cause of the transfer of typhoid and of other water bacterial disease. In this connection it must be remembered that bacteria are not killed by the cold.

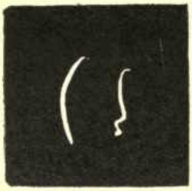


Fig. 19. Ankylostoma duodenale, male and female. Natural size. (Simon.)

Quite apart from diseases due to bacteria in water are the disorders associated with a high content of mineral matter in the water. It has been noticed that a change to hard water from soft water may cause constipation and a change back again unusual looseness of the bowels. From 10 to 15 parts of inorganic salts per 100,000 is to be regarded as undesirable. The use of hard water probably has no connection with stones in the bladder. The disease most commonly associated with water, apart from its bacterial content, is goitre. There can be no doubt but that in certain districts, where goitre is frequent, the cause of the hypertrophy of the thyroid gland is to be found in a filterable agent

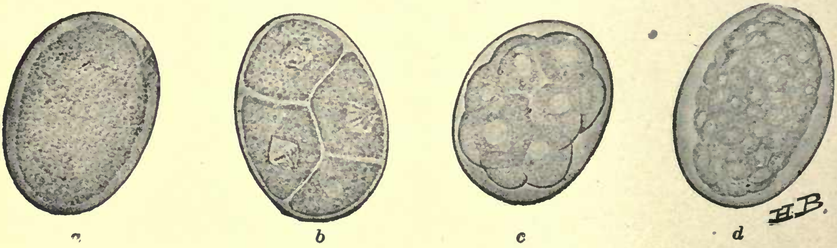


Fig. 20. Eggs of uncinaria duodenalis. a, unsegmented; b, with four segments and showing nuclear spindles; c and d, later stages of segmentation. X 400. (Wilson.)

passing into the water, either as an infusion from some organic constituent, or as the result of bacterial action upon the organic sediment in the water.

HABITATIONS

The houses in which human beings live and the buildings which they frequent have much to do with health.

Sunlight—The more sunlight which a house can receive, the more hygienic will be the interior of the house. This means that the windows must be large and numerous and the house, whenever possible, so placed that sunlight will stream into it during most of the day. If the front faces the South, the opposite side of the house will face the North and receive no sun. Consequently, it is better that the corners of the house should face the points of the compass; when such is the case, all sides of the house will receive some sunlight during the day.

Construction of Houses—As regards the construction of the house, stone or concrete unquestionably furnish the warmest house in the winter and the coolest in the summer. Concrete is better than stone, as it does not retain dampness. Clapboards have many advantages in permitting good ventilation through the walls, though they are wasteful of the heat.

No portion of a house is of greater importance than the cellar. Its floor and walls must be impervious to gases and water. This condition is generally best accomplished by a generous layer of cement.

Roofs must be light and slate or asbestos shingles or tiles are much to be preferred to shingles. Tin is poor, as it is hot and apt to rust. Gravel and tar are very good for flat roofs. The gravel protects the tar against the action of the sun.

An important part of the house is the kitchen and its immediate surroundings. All that pertains to the kitchen must be clean No filth or waste should be permitted to remain in any receptacles in its vicinity. The daily waste should be kept covered. There should be no necessity for a "spring cleaning" for the perfectly clean house knows no cleaning seasons. As regards methods of cleaning the rest of the house, nothing equals an efficient suction

cleaner. No dust is made by these cleaners; that is, the dirt in the room is not simply dusted off from one place and allowed to fall on another, but is taken from the place where it may happen to be, directly into the cleaner, from which it may be taken outside without scattering it again through the house.

Schools—The windows of schools should be large and numerous, and in their total sectional area should equal one-tenth to one-fourth of the total floor space. The desks should be so placed that the light comes from the left of the pupils, in order that their bodies and pens will not cast shadows. They should have a slant of 10 to 20 degrees. The chairs should be comfortable, with straight backs and seats, which support the bodies in the middle of the thighs. The cloakrooms should be spacious and well ventilated and allowing plenty of room between each child's clothing.

Water closets and urinals demand unusual care, inasmuch a children are prone to carelessness in these rooms. Blackboards should have a dull black finish and never placed between windows. Copying from the blackboards should not be encouraged on account of the constant strain upon the eyes incidental to frequent change of focus.

Ventilation—Each individual requires 3,000 cubic feet of air hourly. This will not furnish the individual with the ideal conditions of out-doors but will keep the percentage of carbon dioxid down to .6 to 1 volume in 10,000, and this is good ventilation. Artificial lighting greatly increases the consumption of oxygen and the impurities in the air in the room. About 3 to 5 cubic feet of gas are burned from an ordinary burner per hour and require for their proper dilution 1,500 to 10,000 cubic feet of fresh air.

The impurities added to the air by illuminating gas are carbon monoxid, the sulphur acids, the nitrogen acids, marsh gas, ammonia compounds, and unconsumed carbon. Calculated on the basis of quantity of light produced, candles and kerosene lamps produce 40 to 160 times as much impurities as illuminating gas.

Every building must, therefore, possess some means of constantly supplying fresh air to its interior.

Natural Forces of Ventilation—There are many natural forces in ventilation.

Diffusion—Each gas possesses its own coefficient of diffusion

proportionate in general to its molecular weight and of 2 cases the rate of diffusion into each other is proportional to the square roots of their densities.

Diffusion, as a force for eliminating from a house objectionable gases and providing in their place fresh air, is a totally inadequate means of ventilation.

Gravitation—Gravitation is a stronger force in ventilation than diffusion. It is greatly assisted by temperature. In any inhabited room there are always sources of heat which create convection currents. The sources of heat are the individuals inhabiting the room and the artificial heating and lighting devices.

Winds—Currents of air either from gravity currents on the inside or the current of winds on the outside will pass through most of the materials composing the walls of a house, including, certainly, brick and stone. Wall paper, paint, and tight joints all oppose these natural forces of ventilation, but notwithstanding the drawback of these conditions, from which we cannot always be independent, much may be accomplished by supplying intelligently placed inlets and outlets. In warm weather large and numerous windows which may be left open will permit of diffusion, and allow the natural currents in the air to supply a sufficient quantity of fresh air. During the winter, however, every quantity of fresh air brought from the exterior must be heated and the greater the ventilation the greater the amount of heat which must be produced inside the house. The aim in ventilation, therefore, should be to adjust the renewal of air so that an unnecessary waste of the heat produced within the house should not occur. It is better, therefore, to provide a house with fairly tight walls and to provide for a definite plan of ventilation within the house. Such a plan includes provision for inlets and outlets.

Inlets and Outlets for Ventilation—A simple form of outlet is the cowl. The ordinary type of rotary cowl constitutes obstruction to the egress of air rather than otherwise. The aspirating cowl, on the other hand, opens horizontally and is always held by a vane above it in the direction towards which the wind is blowing. It constitutes an efficient aspirating device. Cowls may be placed over chimneys or ventilating flues (Figs. 21, 22 and 23).

Windows with boards placed beneath them constitute simple inlets and outlets. The cold air from the inside strikes the lower

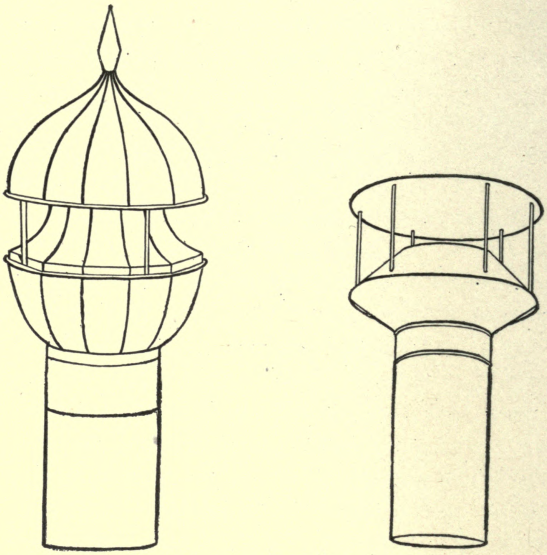


Fig. 21. Common forms of stationary ventilating cowls. (Harrington.)

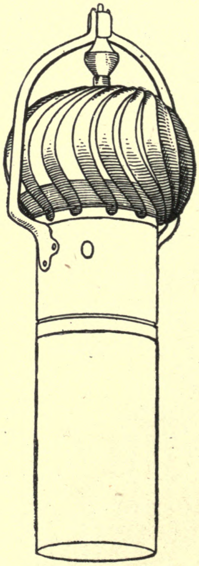


Fig. 22. Rotary cowl. (Harrington.)

sash and is thrown upward between the lower and upper sash into the room. Due to its original force of entrance it rises toward the ceiling. From here it falls toward the floor. In its passage in this manner through the room, it creates currents which assist in thoroughly mixing the air in the room. In the usual house the lowering of the upper sash of certain windows upon the windward side of the house and of others upon the side upon which the wind creates aspiration currents, will provide for the

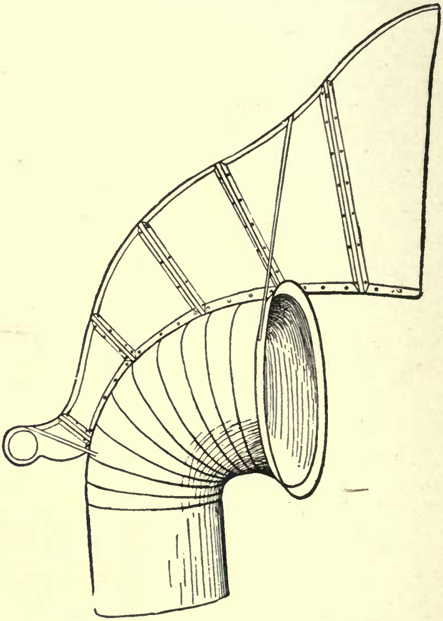


Fig. 23. Aspirating cowl with vane. (Harrington.)

entrance of fresh air, which will become warmed in its passage towards the floor and the removal of the warmed air which has passed upwards toward the ceiling. In buildings occupied during only a small part of the day, as some schools and churches, special means of ventilation may be dispensed with and dependence placed upon a thorough airing after use.

Special Means of Ventilation—When it is desired to provide for special means of ventilation, it may be done sufficiently only by provision for properly placed inlets and outlets and of suitable means of heating. The underlying principle is that there should

be a thorough blending of the incoming air. The inlets and outlets should not be so placed as to favor a direct current between them. In general the inlets should be placed on the inside wall and as near as possible to the center of the horizontal length of the room. If the incoming air, entering through these inlets, is heated, the inlets may be placed high or low; but if the incoming air is not heated, the inlets should be at least above the heads of the occupants.

Part of the air which has entered and risen to the ceiling comes into contact with the windows and cooler outside wall of the room and this portion then sinks toward the floor and becomes sucked toward the inner wall by the aspiration currents set up by the rising of the entering air and by the aspiration through the outlets which should also be on the inside wall. If the incoming air is heated, the outlets may be high or low, but if the incoming air is not heated, the outlets should be high, as in this case the colder air entering sinks to the floor and then becoming heated, rises, carrying with it the other impurities in the room, and if it now meets the outlets placed high it will be removed at a proper time.

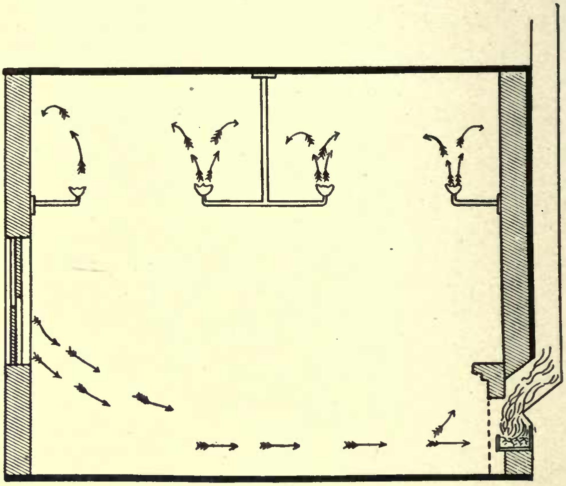


Fig. 24. Direction of air-currents in room lighted by gas and heated by open grate. (Egbert.)

The efficiency of the inlets and outlets is greatly increased by the creation in them of currents of air, depending, in the case

of inlets, upon mechanical propulsion, and in the case of outlets, upon heating the air in the flue beyond the connection with the room (Fig. 24). Only one of these methods is needed, as if air is forced into a building by mechanical propulsion it must necessarily displace the used air already within the building. And, if air is aspirated out of the rooms of a building by heated flues, the aspira-

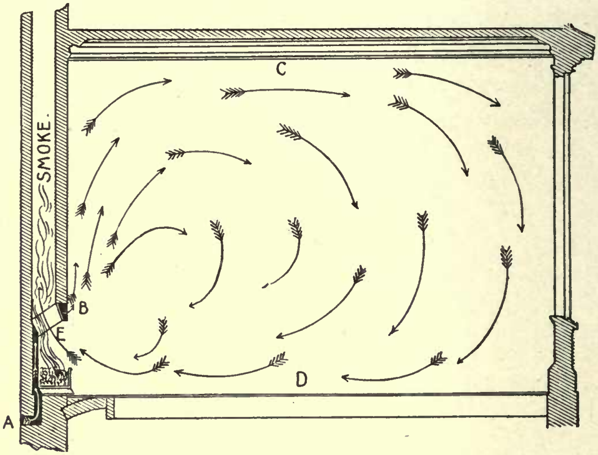


Fig. 25. Direction of air-currents in room heated by a ventilating grate. (Egbert.)

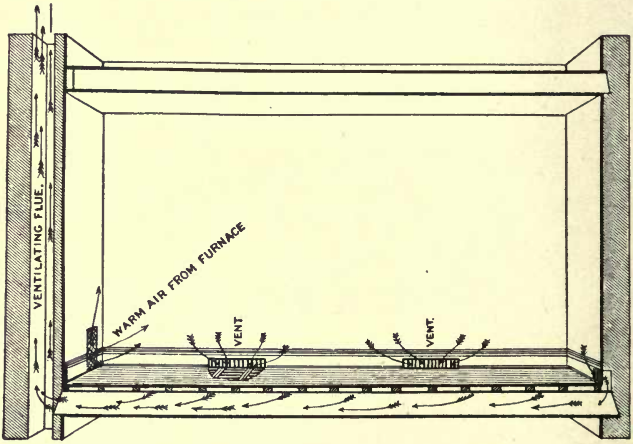


Fig. 26. Illustrating the Smead system of ventilation. (Egbert.)

tion must create a lower pressure, which will determine the drift of fresh outside air to take the place of the air removed (Figs. 25 and 26).

The Quantity of Fresh Air Needed per Individual—In calculating the quantity of fresh air which it is necessary to supply, provision must be made against the occurrence of perceptible draughts. It has been demonstrated that 2,500 cubic feet can be passed without draughts through a space 8 x 8 x 6.5 per hour. It will thus be removed six times. The minimum space allotted to each individual, therefore, should be 500 cubic feet. In larger spaces the changes can be more frequently made without creating draughts. Thus, in a hall 40 x 20 x 15, 40 persons may get 3,000 cubic feet per hour with an allowance of 300 cubic feet to each individual without a draught.

In large halls, churches, etc., 300 cubic feet per hour for each individual is not practical nor necessary, insomuch as such spaces are occupied for only short periods.

Even in houses much economy may be obtained by recognizing that much of the space is only temporarily occupied. To insist even on 1,000 cubic feet of air space with renewal each 20 minutes is to demand an unnecessary waste of energy and money.

HEATING

The subject of ventilation is intimately associated with heating. The methods by which a house is heated have, it may almost be claimed, all to do with the distribution of the air within the house and with the withdrawal of used air and even the supply of fresh air.

Heat is imparted in three ways:

1. By radiation.
2. By conduction.
3. By convection.

Radiation—Air is transparent to heat. The drier the air the less is the heat which is retained by it. Heat passes through air and is reflected and absorbed by objects in its path according to their color, surface, and temperature. The intensity of radiant

heat varies inversely as the square of the distance from the source. A good example of radiant heat is the heat furnished by the open fire.

Conduction—The transmission of heat from one particle of matter to another in direct contact with it. No substance is absolutely non-conductive, but metals are far better than wood, woven materials or asbestos.

Convection is heat conveyed by liquids or gases in motion. Such gases and liquids become warmed and pass upwards and are in time replaced by other liquids and gases, which come in from the side.

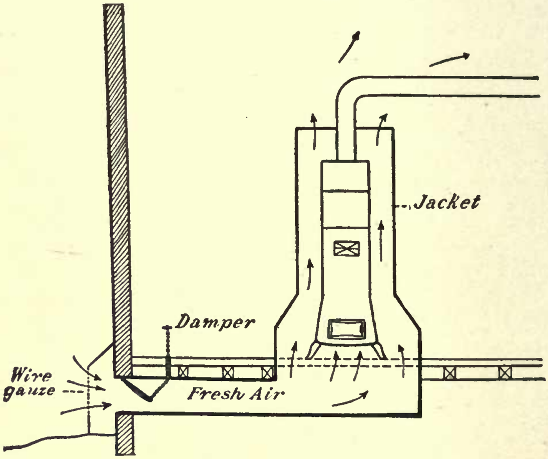


Fig. 27. Jacketed ventilating stove. (Harrington.)

Convection currents are set up by all heated subjects in a room, including the individuals themselves.

Open Fires and Stoves—Heating by radiation is illustrated by the use of an open fire or stove, though to some extent it is also heating by conduction.

The efficiency of the stove is increased by surrounding it by a cylinder which increases the amount of conduction from the stove and also sets up some convection currents (Fig. 27).

Heating by open fires greatly increases the cheerfulness and ventilation of a room but they are not an economical method of heating. Stoves are more economical, especially when sur-

rounded by a cylinder of sheet iron. This cylinder may be so arranged that fresh air may be taken in from the outside and warmed by conduction and applied to heating the room by convection.

Stoves consume much oxygen within a room and are very liable to give off carbon monoxid gas. This may be guarded against by insuring complete combustion (Fig. 28). In this connection it must be remembered that red hot stoves may transmit carbon monoxid gas through their walls.

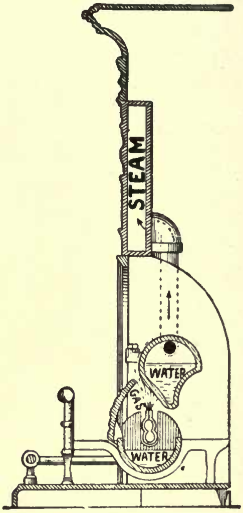


Fig. 28. Section of Backus' portable steam radiator for use with gas, insuring complete combustion and the supply of moisture to the air in the room. (Egbert.)

An oil stove is really preferable to a coal stove, for while it also discharges its products of combustion into a room, these, in the case of the oil stove, are carbon dioxid and water.

Houses may be heated from a central heating station in the house. These stations may be hot air furnaces, hot water furnishing systems or steam furnishing systems.

Hot Air Furnaces—Hot air furnaces possess enormous ventilating power. The heated air replaces or drives out the colder air within the house.

Hot Water Systems—In these systems the building is piped

with pipes which are filled with water and communicate with water heated in the furnace. Convection currents are set up in this water, which transmits this heat to all parts of the house. Vents for the discharge of air must be placed in the system and a return flow of the water also provided for.

Heating by Steam—In heating by steam there is also a system of pipes, which communicate with the boiler over the central heating station. Steam is evolved within this boiler and is conveyed by the pipes to all parts of the house. This method of heating by steam is called the direct method.

In the indirect method the steam pipes do not enter the room but the outside fresh air heated by passing over the pipes is then passed into the room.

The most satisfactory of these methods considered from the standpoint of expense, efficiency and all-round serviceability, is the hot water system. This system may also be more easily regulated to suit the extensive variations in outside temperature occurring through all the cold months of the year.

In any system of heating it is important to provide for the proper supply of moisture. Nothing is more deleterious to the healthy conditions of the mucous membranes of the respiratory passages of the individual than the abnormally dry atmosphere of the houses dry-heated. Provision should be made for keeping the relative humidity up to 50 or 55 per cent.

LIGHTING

Natural Lighting—In the usual house or building in the town or city, the daylight entering through the windows is sufficient during the day. In many buildings in the largest cities even in the day sufficient light from the sun is not obtained without assistance. In many such instances sufficient additional assistance is obtained by placing ribbed or, better still, prismatic glass either in the windows or constructing hoods of such prisms and swinging them as eaves or porchcovers above the windows. By thus refracting the light it is thrown directly into the rooms (Fig. 29).

Artificial Lighting—Artificial light must be depended upon in certain other buildings during the day and at night in all buildings.

For artificial lighting, until recent times, nothing better was known than oil or candle flames or more recently gas flames.

Flames—Every flame consists of 4 portions. The lowest portion is blue and gives no light. The middle portion is dark in color and consists of hydrocarbon generated from the oil candle, or in the case of the illuminating gas of the gas supplied. Next, the luminous part of the flame, which consists of incandescent particles of carbon which are passing outwards in a heated state having escaped complete combustion in the oxygen passing inwards from the outside space, which oxygen is insufficient to unite with the carbon of this portion of the flame. In virtue of its greater affinity with hydrogen the oxygen unites with it, thus furnishing the heat to illuminate the particles of carbon. Still more externally in the flame is a second colorless portion, in which portion, being nearer the supply of oxygen, there is sufficient oxygen to oxidize the carbon to carbon dioxid. If the area of the outside surface of the flame is sufficiently small, enough oxygen cannot be taken to unite with all the carbon and the unsatisfied carbon passes off as smoke. Defects in the burner or excessive richness may produce the same effect. If, on the other hand, the area is too large, there

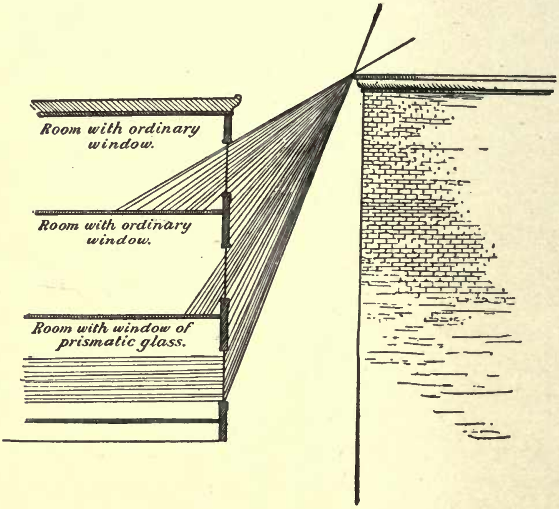

Room with ordinary window.
Room with ordinary window.
Room with window of prismatic glass.

Fig. 29. Action of prismatic glass in projecting light. (Harrington.)

may be a simultaneous combustion of the hydrogen and carbon of the hydrocarbons with no luminosity. This same end may be accomplished by the excessive supply of oxygen provided by the Bunsen burner.

Gas Burners—Gas burners are so designed as to give large surfaces and 2 forms are in use: the bat's wing burner, consisting of a narrow slit which spreads the gas in a flat, concentric sheet, and the fish-tail burner, which consists of 2 little holes side by side. The bat's wing burner is the best.

The Argand Burner—The Argand burner provides for a circular flame supplied through the center by means of perforations below in the holder for the chimney to allow an abundant supply of air.

The Welsbach Burner—The Welsbach burner consists of a Bunsen burner supplying the gas beneath an incombustible material which becomes intensely luminous in the heat of the flame. One of the commonest and best mantles is made by soaking a delicate cotton network in a strong solution of earth oxids (cerium, zirconium, lanthanum, and thorium). When lighted, the cotton burners give out more light with less expenditure of gas than even the Argand burners. Burners on the same principle may be used with kerosene. The combustion in these burners may be made complete with far less danger of the incomplete combusted products escaping into the room.

The following are the varieties of gas used for illuminating purposes:

Coal Gas—Coal gas is made by heating bituminous coal in fire clay retorts by which the compounds of hydrogen and carbon are transformed into gaseous and other products. By condensers and other purifiers it is freed from ammonia, hydrogen sulphid, tarry and other impurities. The purified product consists of 50 per cent of hydrogen, 35 per cent marsh gas, 60 per cent carbon monoxid and the remainder of ethylene and other hydrocarbons and nitrogen.

Water Gas—Water gas is made from coke or anthracite coal, steam and petroleum.

The coke or coal is placed in an air-tight cylinder lined with fire clay ignited and blown by a blast to a white heat. Then the air is suddenly shut off and steam is blown in. By the great heat

the steam is decomposed into hydrogen and oxygen. The oxygen unites with the carbon, forming carbon monoxid, leaving the hydrogen to pass in uncombined. The mixture is then carried to a carburetter chamber of fire brick, kept at red heat within which petroleum is injected and volatilized and mixed with the hot gas.

Relative Toxicity of Coal and Water Gas—The final product smells like coal gas, but has a very different composition. It is far more poisonous, as has been demonstrated in Boston by statistics of the deaths from gas when water gas was substituted for coal gas. It contains 30 per cent of carbon monoxid, 35 per cent of hydrogen, 20 per cent of marsh gas, ethylene and nitrogen.

The poisonous qualities of either coal or water gas are due to the carbon monoxid, only 0.4 per cent in the air is required to produce fatal results, but even less is fatal after long exposures.

Acetylene Gas—Acetylene gas is an unstable hydrocarbon $C_2 H_2$ mixed with air, 1:19. It is violently explosive. It is poisonous, but not to the same extent as coal gas. It produces unconsciousness without excitement and death after prolonged exposure. Burned in the ordinary way it smokes, but by using a thin slit and by forcing the gas through under pressure, it gives a very brilliant flame, 15 times that of ordinary gas.

Gasolene Gas—Gasolene gas is a mixture of gasolene vapor and air. The air is simply a diluent. The gas is generated and forced by supply pipes to the burners by an apparatus which requires little attention in contrast to acetylene. It is well suited to single houses.

Disadvantages of Gaseous Illumination—The use of gaseous illuminants possesses many disadvantages. First of these is the consumption of the oxygen in the room and the giving off of poisonous gases into the air of the room. These products are of least importance from candles or lamps, but are considerable from illuminating gas. They include carbon monoxid, sulphur dioxid, and ammonia compounds.

Second, among the disadvantages, are the danger of leaks and the collection of condensed water in the pipes which causes flickering. Flickering may be avoided by the use of drip cups. Gas fixtures should never be placed in draughts or over heaters.

Electric Lighting—Electric lighting entails none of these disadvantages. It in no way alters the air of the room. It imparts

little heat. Nothing has surpassed the tungsten or new nitrogen tungsten globe in the approach to ideal artificial lighting. The matter very directly affects health and the preservation of the eye, one of the most important possessions of man.

PLUMBING

Relation of Good Plumbing to Health—The importance of plumbing has unquestionably been over-rated. The suggestion that defective plumbing is injurious to the health is a strong one from the nature of the waste which plumbing cares for. As a matter of fact, dangerous bacteria are not transmitted easily by a defective system of plumbing. However, indirectly, poor plumbing may be a source of ill health. Bad odors from defects in plumbing or a knowledge of improper conditions in this regard may affect the appetite and thus seriously injure the nutrition of sensitive individuals.

Contamination of the Air with Bacteria with Defective Plumbing—Because bacteria may not easily be transmitted by defective plumbing from sewage, it does not mean they never are. That they may be, has been demonstrated by the plate experiments already referred to.

Conditions Constituting Good Plumbing—No system of plumbing should, therefore, be tolerated which leaks either liquid or solid matter or foul air or smells.

All fixtures on each floor should be in relatively a vertical line. The waste pipes should be accessible and pass in such a manner that they shall be in full view so that leaks may be easily detected. The important fixtures, such as bath tubs and water closets, should be placed where ventilation is abundant and free and where dependence upon artificial light is not altogether necessary. The ideal place is in an outer room furnished with a window through which fresh air and sun rays may easily enter.

The soil pipe is the pipe which connects the various waste pipes of wash basins and tubs and water closets with the drain pipe. They are, therefore, the vertical pipes running from the various floors to the cellar. They are preferably made of cast iron. The spigot end of one fits into the limb of another. The front should

be made tight by calking and then pouring melted lead down upon the oakum and pounding the lead tightly into the groove. Better still, perhaps, is to bolt the two pipes together. Each separate soil pipe should extend 2 feet above the roof of the house and they should not be covered with a cap or cowl. Whenever it is necessary to provide for a bend in a soil pipe, it should be done with an elbow piece and the unions made with Y pieces (Fig. 30).

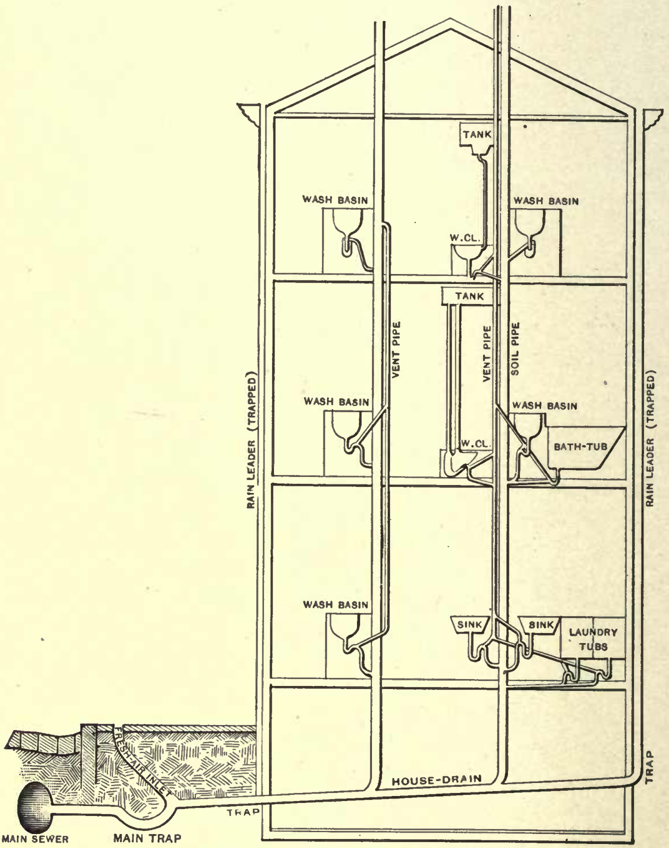


Fig. 30. Illustrating sewage-plumbing of a house. The traps of the rain-leaders at their junctions with the house-drain have been accidentally omitted. (Egbert.)

The pipe connecting the bottom of the soil pipe with the sewer

pipe outside of the house running, therefore, with a tilt slightly off the horizontal is called the drain pipe. The drain pipe must be of iron and run to a joint external to the cellar wall and well away from it. The drain pipe may be suspended from the cellar ceiling or, if it can be buried, it may be placed beneath the cellar floor, but should, nevertheless, be accessible and have a pitch of ¼ of an inch to the foot and without lap. At the place where the drain leaves the cellar wall or at least just outside of the foundation walls within a manhole there must be an intercepting trap. The construction of the trap should be such that the outlet end of the trap is slightly lower (2 inches) than the inlet. The inlet end should be back-aired, preferably in front (the house side) of the trap. The pipe furnishing the connection with the surface air should be of the same diameter as the drain pipe (Fig. 31).

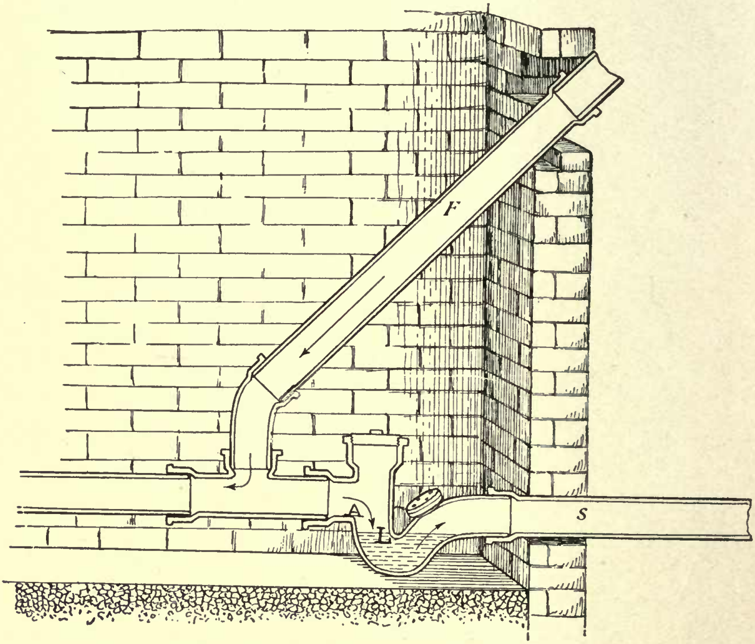


Fig. 31. Preferable arrangement of intercepting trap and ventilating pipe. (Harrington.)

Figs. 32 and 33 represent proper and improper connections of another form of vent pipe.

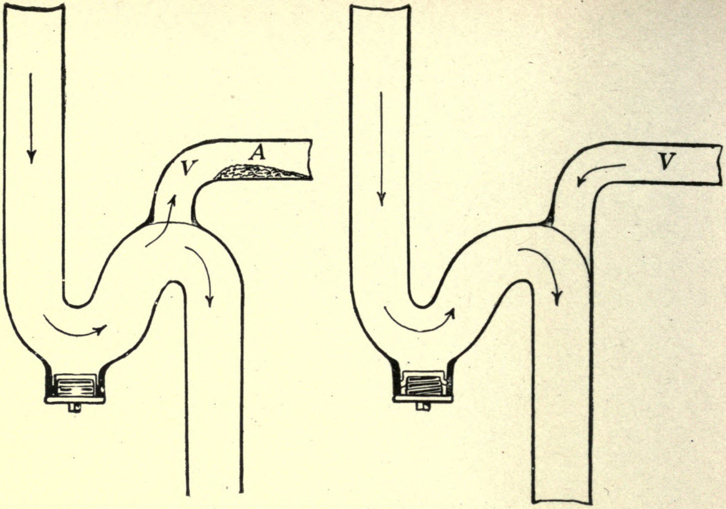


Fig. 32. Improper and proper positions of vent pipes. (Harrington.)

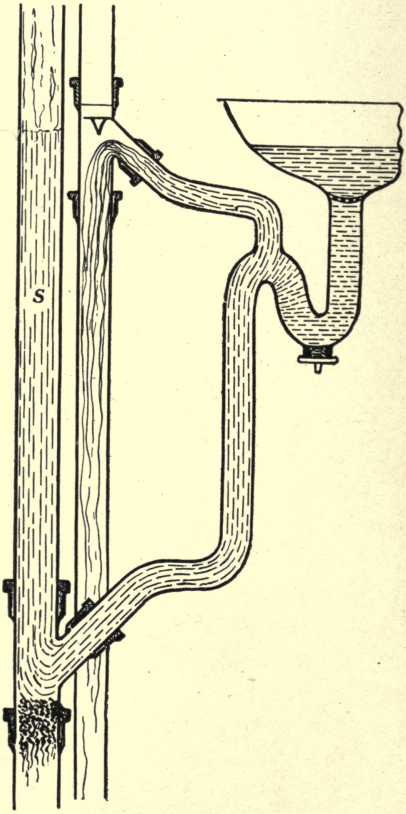


Fig. 33. Improper junction of vent pipe with main vent. (Harrington.)

By the seal of the trap is meant the depth of the water in a U-shaped trap above the highest horizontal line which passes without interruption from the inlet side to the outlet side of the trap. It should never be less than 1.5 inches.

Traps of many different shapes have been made. None is better than the single running trap. Bottle traps, ball traps, bell traps, and grease traps all have been designed for special purposes, but the simplicity of the U-shaped trap gives it superior advantages (Fig. 34).

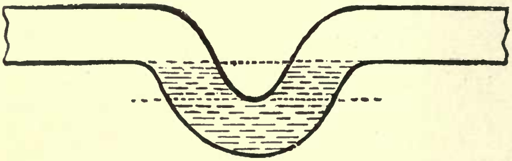


Fig. 34. Running trap. (Harrington.)

SEWAGE

The Sanitas trap, invented by J. Pickering, though not so simple, possesses the advantages detailed with the legend Fig. 35.

With the invention of the water closet in 1810, the question of the hygienic disposal of sewage began to be first seriously considered.

The best form of water closet is the "Sanitas" (Fig. 36). It is provided with a syphon tank valve, a good flushing run, an efficient siphon pipe and it makes practically no noise. Other forms of self-siphoning closets are illustrated in Figs. 37 and 38.

Wash basins (Figs. 39 and 40), bathtubs (Figs. 41 and 42), and washtubs, are best made of iron with porcelain enamel.

Domestic and Industrial Sewage—With the invention of the water closet and the more general introduction of the public water supplies, the separation of domestic sewage, including the wastes from toilets, basins, bathtubs, kitchen sinks, and laundries, from industrial sewage composed of the wastes from establishments, like paper mills, tanneries, dye houses, and factories, etc., was no longer maintained. Both together constitute municipal sewage.

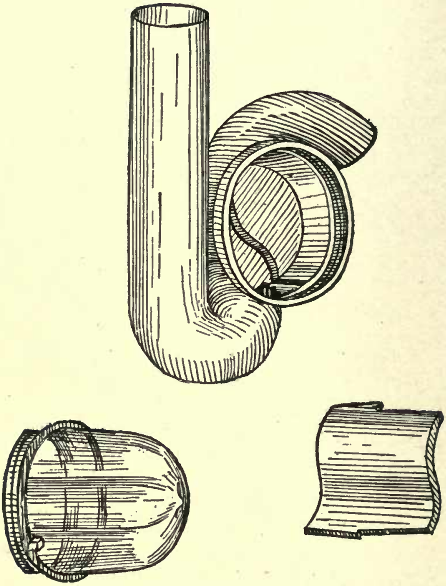


Fig. 35. Sanitas trap (taken apart) showing the deflecting partition within the chamber which permits of the passage of air above the water and throws back a volume of water sufficient to maintain a seal over three inches in depth, which resists evaporation for a long time and cannot be destroyed by capillary attraction. The trap is made proof against siphonage. When attached to fixtures with large outlets and quick discharge it is self-cleansing, even when ashes or similar unusual constituents of sewage are thrown into them. (Harrington.)

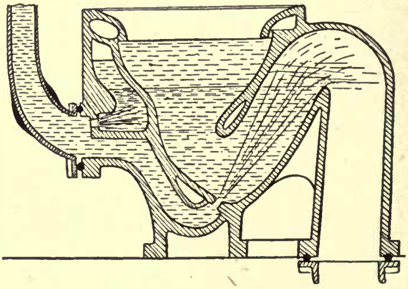


Fig. 36. Sanitas closet.

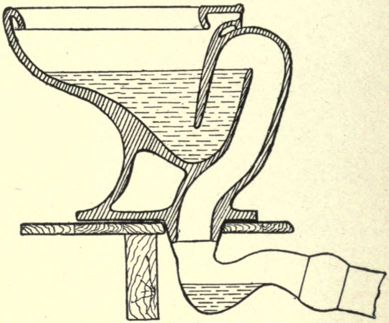


Fig. 37. Dececo closet. (Harrington.)

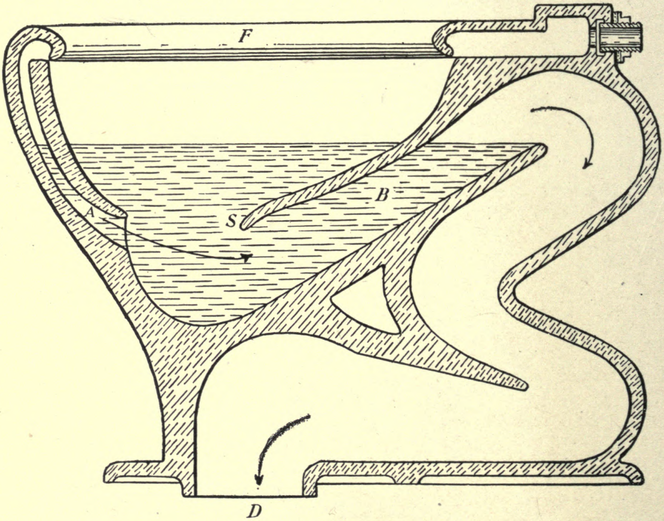


Fig. 38. Siphon jet closet. (Harrington.)

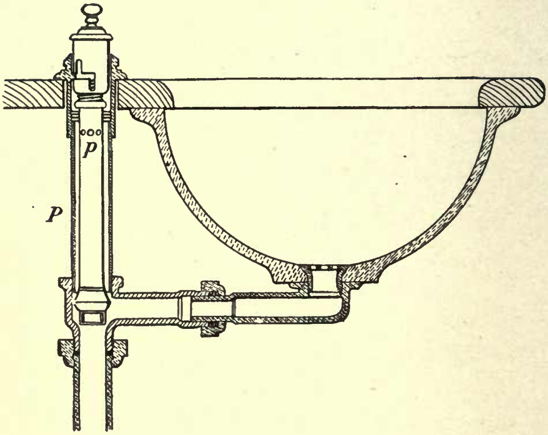


Fig. 39. Wash basin with standpipe plug and overflow. (Harrington.)

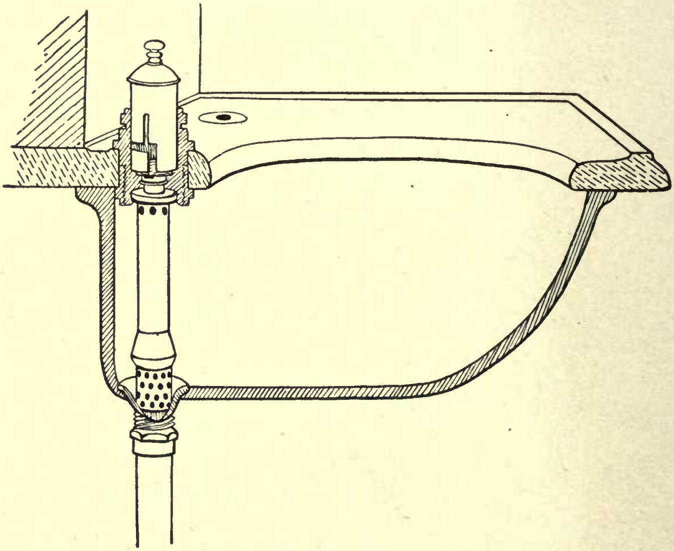


Fig. 40. Improved standpipe overflow. (Harrington.)

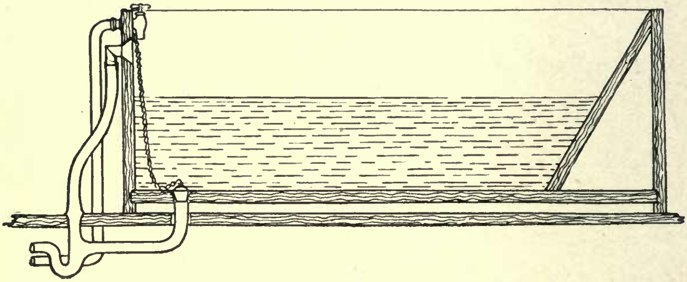


Fig. 41. Vertical section of commonest form of bathtub. (Harrington.)

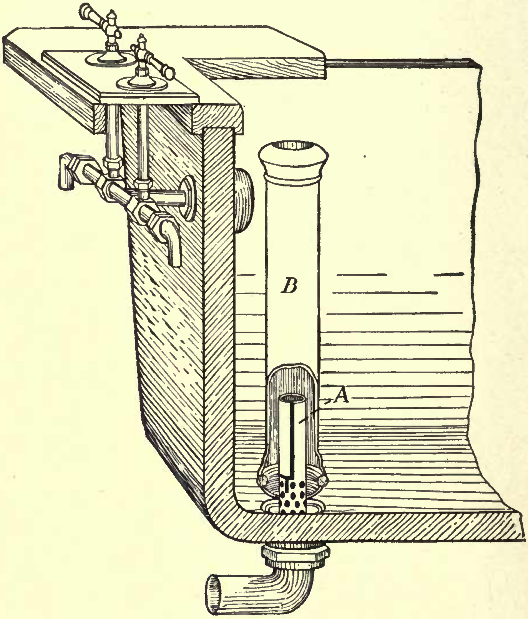


Fig. 42. Standing overflow and waste pipe. (Harrington.)

Manurial Value of Municipal Sewage—As long as domestic sewage was separated from industrial sewage, considerable use was made of the waste from human life for fertilizing purposes and in the minds of many the belief still prevails that municipal sewage possesses great manurial value. Victor Hugo has forcibly expressed this idea in "Les Miserables," beginning thus: "Paris casts 25 million francs annually into the sea and we assert this without metaphor by day and night. How so and in what way? For what object? For no object. With what thought? Without thinking. With what object? None. By means of what organs? Its intestines. Etc."

This statement declaring that Paris throws away wealth in golden dung sufficient to pay ¼ of the expenses of the budget is doubtless true. But on the other hand, at the present time it is not economical or hygienically desirable to separate from sewage those constituents of fertilizing value. In domestic sewage, where the water supply is abundant, the organic matter constitutes only 1 per cent and the sewage of Boston has been estimated to be worth about 1 cent per ton and that of New York even less. It is surely not worth its transportation in the absence of the possibility of this being arranged by sewers.

The Disposal of Municipal Sewage by Means of the Sewage Irrigation System—Of the various methods of disposing of sewage, the sewage irrigation system approaches closest to the most ideal and economical method of disposing of municipal sewage. Large sewage farms are provided for the purpose, and upon these the sewage is pumped. There are hundreds of such sewage farms in England and others in Germany, France, India, and America. The success of the farms depends much upon the temperature the year around. That is upon the number of crops which may be grown, the character of the soil, and the amount of rainfall.

No hard and fast rules can be made as regards their operation in relation to the amount of land to be set aside, for instance, per 1,000 people. In general in England, 2,000 to 10,000 gallons are applied daily per acre. In Madras where the soil is loose and the vegetation rank, 75,000 gallons may be received on an acre daily. The best soil for the purpose is one of sandy loam with fine interstitial spaces which will permit not too rapid percolation and within which the process of nitrification may go on thoroughly. A dense

clay soil may be rendered suitable by admixture of sand or lime and by tile underdraining. With a proper care the effluent should be clear.

The farm is laid out in broad ridges separated by furrows into which the sewage flows. The crops grow on the ridges between. At intervals of 6 feet, the whole farm should be naturally or artificially underdrained, so that the purified water in excess may drain off into the natural water courses. The city of Berlin has set aside a tract of 20,000 acres for its sewage farm. The yearly yield of grass per acre is 25 tons, equal in value to 5 tons of hay. The original cost of the farm was $13,000,000 and the entire plant yields annually a profit of $60,000, or ½ of 1 per cent interest, although the labor costs nothing except for the maintenance of the men engaged, who are condemned for minor offenses.

In Madras, where 8 crops a year may be harvested, 69 tons of grass or 25 tons of hay are obtained per acre. It must not be considered, however, that, although in cold climates, the crops cannot be grown in the winter, sewage is not disposed of by the natural forces of purification the year round.

Near Montreal, for instance, it was found that the sewage farm would act efficiently in disposing of the usual amount of sewage in January with a temperature of 20° F. Sewage farms have been proved to furnish no unhealthy conditions to those working upon them. At the Berlin works, in a population of 1,500, there was one death from typhoid in five years. At Gennevilliers, which receives sewage from Paris, there was no typhoid following an extensive outbreak in Paris.

As a source of profit, however, these farms cannot be considered a good investment. Certainly in arid sandy regions, which need artificial irrigation, they are more profitable, but in regions of the world where feasible conditions for irrigation sewage do not exist, it cannot be considered a good investment; and it is more economical to dispose of sewage in other ways. The waste of any valuable fertilizing material in communities, so situated that sewage farming is not advisable, by deliberately turning the sewage properly purified into water courses, must be regarded as so much spent for the health of the community. It is far better to allow other natural forces of conservation to provide for the return of the nitrogen to the air.

The Discharge of Sewage into Water Courses—In the large cities situated on rivers and on the sea, sewage is best disposed of by discharging it into either of these bodies of water. It becomes so diluted that only under exceptional and quite avoidable circumstances does it become a nuisance much less a danger to the health. There must be, however, sufficient current to rapidly dilute the sewage. With a movement of water of less than 1½ miles per hour there are likely to be deposits made which become a nuisance. In inland rivers the sewage is best delivered to some point below the city or town.

Studies by the Massachusetts State Board of Health have justified the conclusions, aside from all reference to objections caused by the manner of discharge of sewage and considering only the question as to whether objectionable conditions exist in the various streams into which sewage is discharged, that where the flow of a stream exceeds 6 cubic feet per second per 1,000 persons discharging sewage, objectionable conditions are unlikely to result.

Purification by Sedimentation and Chemical Precipitation—In many places, however, a partial purification of sewage before its discharge is possible. This may be accomplished by sedimentation and chemical precipitation. Sewage is rendered far more fit to discharge into water courses by the removal of solid material in suspension in it. If this is done the natural forces of the purification of the remainder are relatively and quickly efficient. Practically, therefore, any sewage disposal system of any size should be and is provided with settling tanks. In these tanks, precipitation is hastened by chemical treatment of the sewage. The effluent liquor after such treatment will contain only 1/3 as much suspended matter as the same sewage after passing through only the settling or septic tank. The sludge or precipitate, it is true, may be three times the amount after the exposure of sewage to the complete process in a septic tank, but the effluent fluid is nevertheless clear.

The sewage flows first through screens which remove the coarser matters. It is then mixed with alum lime or ferrous sulphate. Alum and other soluble salts of aluminum in the presence of lime or ammonia form a very gelatinous precipitate. With an excess of alum the effluent may be acid, but will not contain the unsightly

black compounds of sulphur or iron. Treatment with one ton of precipitate per million gallons costs about $17 per million gallons.

At the Lawrence Experiment Station, during 5 years (1893-1897), sewage was treated with sulphate of alumina (1,000 lbs. per 1,000,000 gallons) and sedimentation 4 hours. This treatment removed 66 per cent of the total organic matter and 78 per cent of the organic matter in suspension, and 68 per cent of the bacteria and 59 per cent of the fatty matters. The sludge after such method of precipitation is most commonly pressed by hydraulic presses and disposed of by burying or filling in of lowlands.

Filtration of the Effluent from Sedimentation Beds by Sand Filters—The filtrate from such sedimentation tanks is then in a much better condition to discharge into water courses or, more ideally, it may be filtered through precisely the same kind of sand and gravel filters which are used for purifying drinking water. These filters care for 75,000 gallons per acre daily. Such sand filters have been in operation at the Lawrence Experiment Station for 20 years. The effluent is a clear, highly nitrified water containing a minimum amount of unoxidized organic matter and a small number of bacteria.

The Bacterial Purifiers in Water—The purifying agents are the anaërobic bacteria which soon establish themselves in the interstices of the filter. In order that both anaërobic and aërobic bacteria may do their work, it is important that filtration should be intermitted with aeration of the filters at intervals.

It should be remembered that the action of these filters, in the presence of some kinds of manufacturing plants, with their sewage substances, such as arsenic or large amounts of grease, which are inimical to bacterial growth, is interfered with. Special provision must control the sewage from such plants. Nearly 30 municipalities dispose of their sewage through intermittent sand filters. The injurious substances should be submitted to proper preliminary elimination or treatment.

Contact Filtration—When proper filtering material is not available, as in England, where sandy soil is the exception, sewage may be purified by the process of contact filtration. Filters for this purpose are simply large beds of coke or other coarse material with retaining walls and tight bottoms and with outlets which can be closed. Sewage is applied in doses until the filters are filled

to the surface. It is then allowed to stand and after the period of standing, during which the organic matter is subjected to bacterial action, the water is slowly drained away. Seven hundred thousand gallons per acre at a depth of 5 to 6 feet may thus be treated daily. Its rate of filtration is, therefore, 10 times that of sand filters. Systematic resting of the filters for 1 week in every 6 is advised. Preliminary treatment to remove the coarser materials is advisable.

Trickling Filtration—Still another form of purification of sewage by bacterial action is by means of the trickling filters. These are constructed of stones ¾ inch to 1 inch in diameter, broken stones or even cinders 5 to 10 feet in depth. The sewage must be distributed evenly over the surface by an automatic sprinkling device. It filters through rapidly and, because of the good aeration of these filters, there occurs a quick oxidation of the putrefying matter, while the larger body of stable matters, and matters rendered stable by filtration, are allowed to pass through. The changes accomplished are essentially chemical. Trickling filters cannot be regarded as substitutes for sand filters which remove practically all the matter in suspension.

They are subject to the disadvantage in comparison to contact filters in that they require a head of water of 8 feet for proper distribution over the surface of the filter. The contact bed is far more inconspicuous and compact, produces less odor, does not breed flies and adapts itself to the irregularities of the flow into it.

The Complete Destruction of Organic Matter in Sewage—It will be appreciated from the description of these various methods of sewage purification that the essential process involved is the adoption of some means of retention of the sewage which will permit of the biological activities of both anaërobic and aërobic bacteria. Both these forms of bacteria perform definite action upon the sewage. The presence of the anaërobic bacteria is essential, and certainly the presence of oxygen is also necessary. Attempts have been made to bring about the complete destruction of sewage apart from filters.

Cameron Septic Tank—Such attempts at destruction of sewage are represented by the Cameron Septic Tank. The initial plant at Exeter consisted simply of a single tank 64 feet by 18 feet by 7

feet deep. The sewage enters the tank slowly through inlets 5 feet below the surface. The sewage enters the tank and passes through sufficiently slowly to allow all organic matter to settle out and be worked over by the bacteria until it is destroyed. The organic matter in solution is subjected to the same action. In practice about 10 to 20 per cent only of the organic matter is destroyed.

In such a tank the anaërobic bacteria are the chief agents in the destruction of the organic matter. A modification of this tank which gives them a still further opportunity for activity and submits the remainder of the sewage to oxidative processes is more successful.

The Nuhoff Tank—The Nuhoff tank, based upon the conception of Dr. Travis, which was worked out at Lawrence, Massachusetts, accomplishes a more complete purification of sewage. This tank consists of 2 cylinders 30 feet deep with conical bottoms. These cylinders open into the bottom of a rectangular tank through which the sewage passes. The solid particles in the sewage settle into the bottom of the cylinders. Within these cylinders the sludge is worked over by an anaërobic bacteria, the gas being diverted from the upper tank by baffles. The sludge is held in the lower chambers for a series of months, and when necessary forced out through their bottoms and spread out on beds, upon which it dries quickly, and is then removed to the place of final disposal. It is then without odor. The main body of the sewage passes over the 2 cylinders and on to some form of filter for further purification by means of oxidative processes.

The principle then virtually amounts to the separation of a large part of organic matter by a settling process and the destruction or radical change of a large part of the separated matter by means of the anaërobic bacteria and the purification of the remainder by chiefly the biological oxidative processes.

The Waring System for Separate Houses—On a small scale this method of purification is accomplished by the Waring system. In this system the sewage is discharged through a screen which takes out the paper and other non-oxidizable substances into a reservoir. It empties into a reservoir below the screen through a U-shaped trap.

The reservoir is emptied when it becomes filled by means of an

automatic siphon. It is thus intermittently emptied and time is allowed for the action of the bacteria purifiers, anaërobic and in part aërobic. From the tank the sewage, having been worked over in this manner, flows either into tile pipes arranged in rows and set 10 inches below the ground, or evenly upon the surface of the ground, where it causes no odor or unsightly appearance and where its purification becomes complete.

HYGIENE OF THE ORAL CAVITY

In the section upon bacteriology the part which bacteria play in the destruction of the gingivæ was emphasized. The whole subject of the hygiene of the mouth was summed up briefly in the phrases "efficient drainage of the immediate environment of the teeth" or "cleanliness of the oral cavity."

It is desirable now to further elaborate this subject and to recognize the associated influence of certain purely mechanical factors upon the peridental membrane. The progressive and gradual destruction of this membrane is a consequence of an associated inflammation induced within it, both mechanically and bacteriologically. Such an inflammation produces not only serious consequences, but also a chronic suppurative process between the teeth and the peridental membrane surrounding them. In the consideration of the subject of the hygiene of the mouth, nothing deserves greater emphasis than the fact that the health of the teeth depends more upon the health of the peridental membrane than upon any other single factor.

The fibers of the peridental membrane, passing in several well defined sets of fibers from their attachment within the cementum surround the teeth, pass between the teeth, and between them and the bone of the alveolar ridges. They must be regarded as forming so many supporting slings for the teeth. More than this, the peculiar combination of toughness and elasticity of this membrane, and its sharp edge at its free border where it immediately surrounds the teeth, enable it to maintain its form in such a manner that under normal conditions it sheds fluids and suspended matter within the mouth from off the teeth. This function is so efficiently performed that, when the teeth are normally formed and bear the

proper relation to each other, they may be preserved without decay or any recession of the gingiva until old age. This result may be achieved even in the absence of any other care than the most superficial cleansing, such as merely rinsing out the mouth.

In the normal denture each tooth comes into contact with the tooth next to it at one point called the point of contact. The gingivæ in each space between the teeth, called here the septal gingivæ, normally reach up to or almost to the contact points and slope down on each side, from the crest of the septal gingivæ extending between the contact points. The gingivæ become attached to the cementum of the teeth by the fibers of the peridental membrane a short distance beneath the free margin of the gingivæ. This free margin of the normal gingivæ is sharp, almost knifelike. Between it and the line of attachment of the peridental membrane a space exists completely surrounding the teeth, in which there is no attachment of the gingivæ to the teeth. This space is termed the subgingival space. The area upon the adjacent sides of the teeth below the line of the free margin of the gingivæ is called the septal space, and the areas in front and behind the vertical line of the contact points between the line and the free margin of the gingivæ and the occlusal surface of the teeth are called the buccal and lingual embrasures. (Figs. 43, 44, 45, 46.)

These surfaces are so formed that the secretions of the mouth with their suspended solid particles slide easily off of the teeth and the gingivæ.

As has been mentioned, dental caries is primarily caused by the action of the acid produced by the acid-forming bacteria upon the teeth, but these acids will not be produced in sufficient amounts unless the acid-producing bacteria can establish themselves in recesses or pockets where with them there can also collect deposits of food débris upon which the bacteria may live, and thus produce their life products. Such deposits never occur upon mucous surfaces, but may occur in either defects or fissures in the teeth themselves or in corners between the teeth and the gingivæ when the abnormal relations exist between the teeth themselves and between the teeth and the gingivæ. Again these deposits may occur in pockets produced as a result of destruction to the gingivæ. A defect once started in the surface of the enamel, or even a roughen-

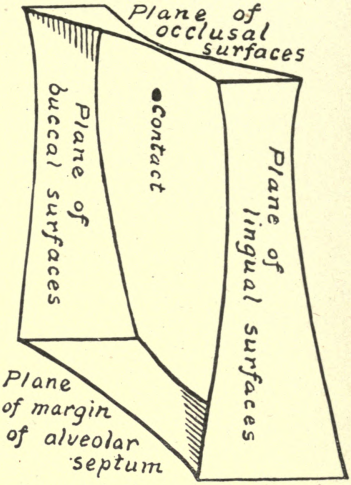

Plane of occlusal surfaces
Plane of buccal surfaces
Contact
Plane of lingual surfaces
Plane of margin of alveolar septum

Fig. 43. Diagram to illustrate shape of interproximal space. If the rectangular frame is placed between two spheres which are in contact at the point indicated, the space within the frame and between the two spheres would be that of an interproximal space between the bicuspids and molars, which might be described as a rectangular section of a biconcave sphere. (Black.)

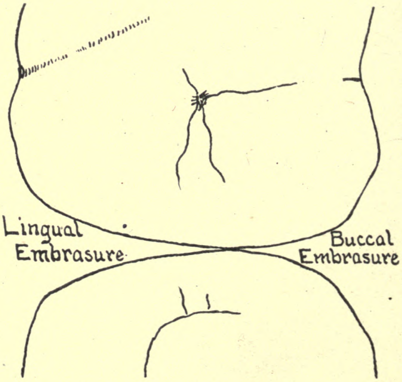
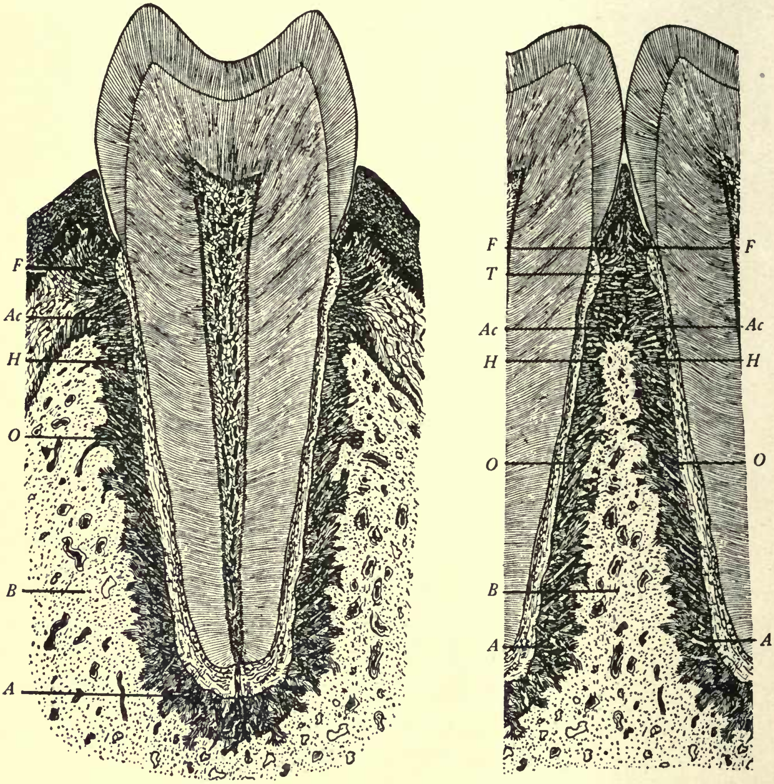


Fig. 44. Diagram to illustrate the relation of the embrasures to the point of contact. The portion of the interproximal space which is normally open (to the occlusal of the septal tissue), is divided by the point of contact into a buccal embrasure and a lingual embrasure. (Black.)

ing of the surface once produced, will gradually become deepened and in itself constitute a place of lodgment for bacterial breeding deposits.



Figs. 45 and 46. Diagrams illustrating groups of fibers of the gingivæ and peridental membrane. Fig. 45. Buccolingual section through a bicuspid tooth and investing tissue. F, Free gingival group of fibers. ac, Alveolar crest group of fibers. H, Horizontal group of fibers. O, Oblique group of fibers. A, Apical group of fibers. B, Bone of alveolar process Fig. 46. Mesodistal section through two bicuspid, one septal, tissues. F,F, Free gingival group of fibers into septal gingiva. T, Trans-septal group of fibers from tooth to tooth. ac, ac, Alveolar crest group of fibers. H,H, Horizontal groups of fibers. O,O, Oblique group of fibers. A,A, Apical group of fibers. B, bony septum of alveolar process. (Black.)

Such primary defects in the teeth and alterations in their normal relations with themselves and the gingivæ constitute one important class of etiological factors in the destruction of the teeth. Aside, however, from this direct action, when these deposits occur

upon the gingival border, they provoke inflammation in the peridental membrane and an inflammation leading to its destruction and separation from the cementum. Such a separation may not only be responsible for the formation of pockets surrounding the cementum which may lodge the acid-producing bacteria, but for the formation of pockets with constantly suppurating walls so that the cementum becomes bathed continually in pus. Such a condition once started becomes a vicious circle and reacts upon the peridental membrane upon one side, causing its continued destruction or deformation, and upon the other side it acts upon the cementum, causing a continued separation of the peridental membrane.

The denuded cementum is sufficiently porous to absorb and to become more or less permeated with the products of the putrefaction within the pockets surrounding it. This increase in the porosity of the cementum contributes to the chronicity of the process. The peridental membrane also becomes detached from the alveolar process and this detachment becomes the principal factor in an absorption of the alveolar process, which also regularly takes place.

The alveolar absorption begins opposite the place on the cementum from which the peridental membrane is detached. With the detachment of the peridental membrane from the cementum there is also a detachment of the cementoblasts and with their detachment a death of the cementum. Cementum differs from all other bone in the body. It depends entirely for its life and power of repair upon the cementoblasts of the peridental membrane. It is a non-vascular tissue. When the cementoblasts are detached its corpuscles die, whether the pulp is alive or not.

This train of events, an inflammation of the peridental membrane, its progressive detachment from the cementum, the death and increased porosity of the cementum and the absorption of the alveolar wall of the tooth follicle, in fact of the alveolar process itself, leads to a gradual progressive loosening of the teeth, until they can no longer be used for mastication and finally fall out.

The whole process is one which is quite different in its main consequences from the causes of dental caries acting directly on the teeth. It must be regarded, however, as not only most serious in its power to destroy the teeth, but also because of its power to destroy life. Too great emphasis cannot be laid upon the

danger coming from the invasion of the body in general by the pyogenic microörganisms thriving in the pus pockets formed by the detachment of an inflamed peridental membrane.

A consideration, therefore, of the hygiene of the mouth must include as one of its most important subjects the prevention of inflammations of the peridental membrane.

Thus far there have been considered two rather distinct causes leading to the destruction of the teeth. First, those leading rather directly to the destruction of the teeth and which act upon localized portions of the teeth and which produce carious cavities of the teeth. Second, those causes producing a primary change in the peridental membrane which leads to chronic suppuration around the teeth and the destruction of the whole denture.

One of these processes may be responsible for the other and both may result from the same etiological factors. They account for two definite pathological conditions within the mouth which are sufficiently separated from each other to constitute pathological entities. They are, namely:

1. Dental Caries.
2. Chronic Suppurative Gingivitis.

In addition to the above there is a third series of pathological conditions, which owe their origin to inflammation beginning in the dental pulp. Pulpitis and the death of the pulp is, however, so frequently secondary to dental caries that it might perhaps be better to classify it, and the train of events following it, as a subdivision under dental caries. Nevertheless, it is by no means always secondary to dental caries. This fact and the very special course of events following pulpitis warrant the consideration of pulpitis as a third group of pathological entities arising in the mouth in association with the teeth.

In brief, pulpitis is most frequently due to direct infection of the pulp from a carious cavity in the tooth. The dental pulp may become inflamed or killed by either a mechanical or thermal shock.

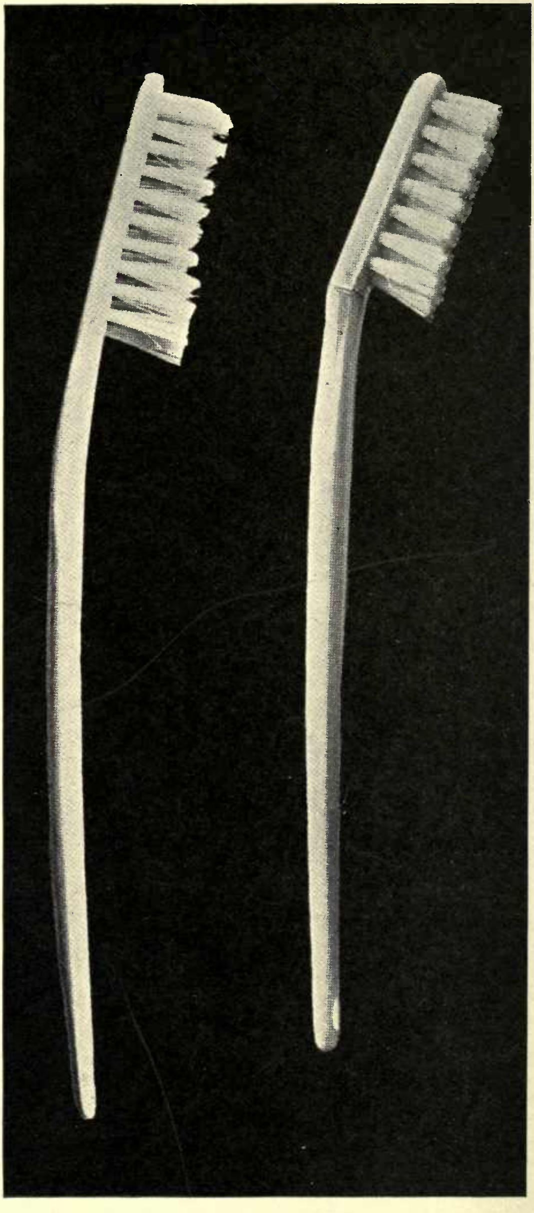
While a pulp may remain necrotic and inclosed for indefinite periods without giving rise to serious consequences, it by no means always does so. The more serious train of consequences frequently following acute pulpitis, and less frequently death of the pulp, is a collection of pus around the apex of the root of the tooth

and a detachment of the peridental membrane in this location. It is a detachment, however, which does not show the same tendency to spread in the direction of the occlusal surface of the teeth, as much as a detachment beginning at the free margin of the gingival processes shows a tendency to spread in the direction of the roots of the teeth. The usual direction of the inflammatory process is externally through the bony canals of the alveolar process. This method of extension soon results in the formation of an abscess beneath the alveolar periosteum, and, depending upon the promptness of proper execution of the pus, the subsequent course of events is either the resolution or the formation of a chronically discharging fistula leading down to the suppurating pulp and walls of the cavity surrounding the apex of the root, or in more unfortunate cases an acute osteomyelitis of almost any degree of severity with severe systemic infection.

The above brief outline of the inflammatory processes originating in connection with the teeth indicates the prophylactic precautions which are necessary to preserve a healthy condition of the teeth. They concern the prevention of the accumulation of any food or other material, including the deposits from the oral secretions, such as salivary or serumal calculus, upon the teeth or in the crevices between them. It also concerns the strict avoidance of any repeated trauma, or other cause of inflammation of the peridental membrane, or thermal, or mechanical shock to the pulp. As has been said, a normal mouth receiving a minimum attention, or the mere rinsing out of the mouth after meals, may suffice to keep the mouth and the gingiva normal for life. For the vast majority, however, a more scrupulous care is necessary. The following rules may be laid down as sufficient for the average patient:

1. Previous to the eruption of the teeth the mouth of the baby needs no special cleansing. The whole care at this period should be devoted to the mother's nipples, or the rubber nipple in case of a bottle-fed baby.

2. As soon as the deciduous teeth have erupted, the teeth should be cleansed with a brush after each meal, at least after breakfast and the evening meal. As soon as the permanent teeth have erupted, the use of a syringe should be added to that of the brush



Figs. 47 and 48. Two tooth-brushes, actual size. Fig. 47 is a splendid brush This is the best form for most persons. Fig. 48 is a similar brush with a greater angle, and is especially good for reaching the lingual surfaces of the lower incisors.

in order to give a more thorough cleansing of the spaces between the teeth and the subgingival spaces.

3. For cleansing purposes antiseptic and tooth powders or pastes are superfluous. Water of a tepid temperature is quite sufficient.

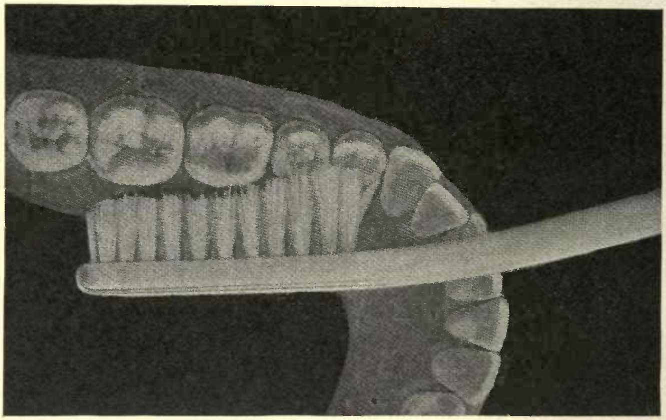


Fig. 49. This shows the position of the brush for the lingual surface of the lower molars. While the brush must be held diagonally to the line of the arch, the movement should be the same as on the buccal side. The brush should be placed on the gum and should then be swept occlusally over the gingiva and teeth. (Black.)

4. Great care is necessary in selecting a brush of proper size and adapted in its shape to the individual. The majority of brushes are too large. Care should be exercised to select a brush

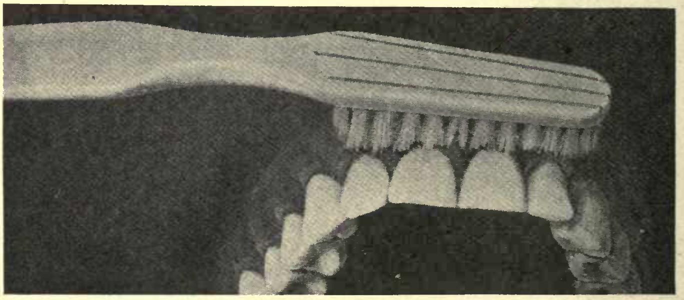


Fig. 50. The brush is shown in the proper position on the gum for the motion downward in brushing the upper front teeth. (Black.)

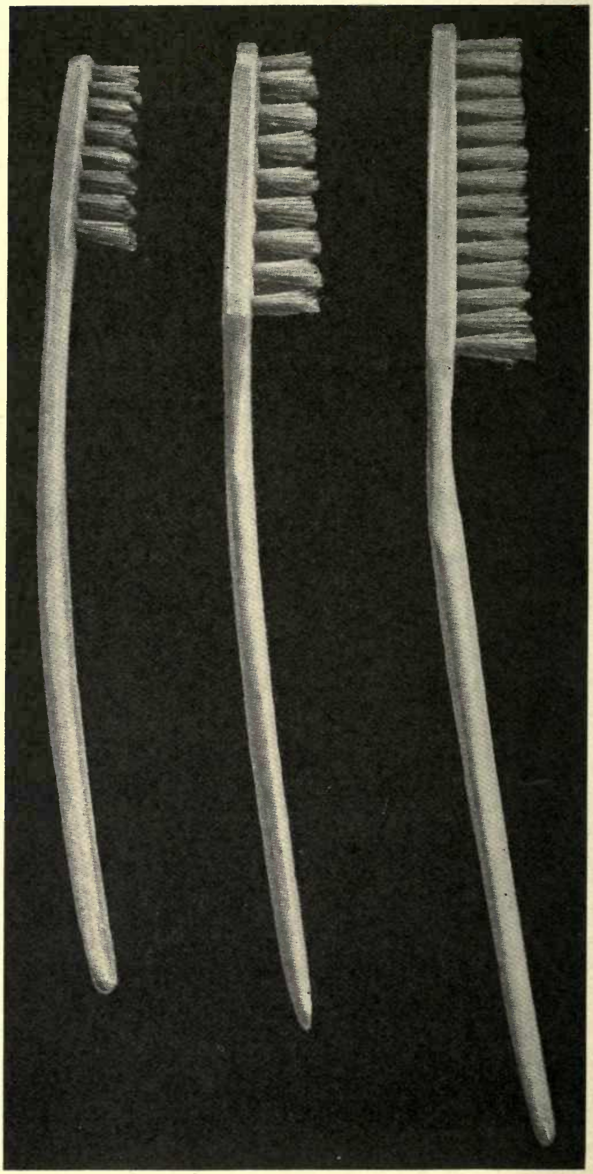
small enough to permit of its free movement in the mouth. As a rule, the brushes sold as youths' are to be preferred for adults. (See Figs. 47, 48, 49 and 50.) The bristles should not be too closely set, there being nearly as much room between the rows of bristles as the individual bunches of bristles themselves occupy. (See Figs. 51 to 53.) A brush of medium softness is preferable. It should have a degree of softness which will permit of vigorous use upon the gums without causing pain. In some mouths the third molars cannot be reached with a brush unless the bristles on the distal end of the brush are cut very short. (See Figs. 54 and 55.) In some instances a brush must be selected with a small separate tuft of bristles at the end which may be carried over the occlusal surface of the third molar and thus reach its distal surface. This may be the only manner in which this tooth may be successfully cleaned in some mouths.

5. The teeth should be cleansed in a systematic manner. It makes little difference what routine is adopted, but it is of importance that no teeth or surfaces should be neglected.

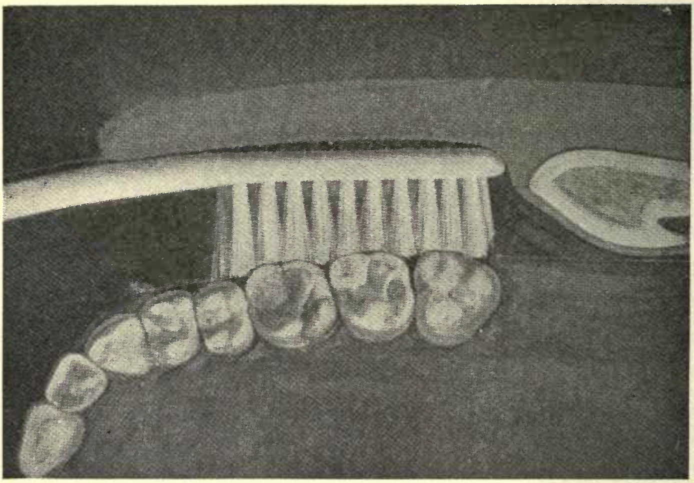
6. The movements of the brush should be rotatory when the labial or buccal surfaces of the teeth are being cleansed. The ends of the bristles of the brush should be made to describe circles around the long axis of the handle moving in a direction from the alveolar process over the gingivæ toward the occlusal surfaces of the teeth. Much the same movements will clean the lingual surfaces of the molars. When the lingual surfaces of the bicuspids and incisors are being cleaned the brush should be introduced over the occlusal surfaces of the teeth, and the lingual surfaces cleaned by a series of pulls in the direction of the handle of the brush. The lingual surfaces should be cleaned by the brush when it is pulled outward in the direction of the occlusal surfaces (Figs. 56 and 57).

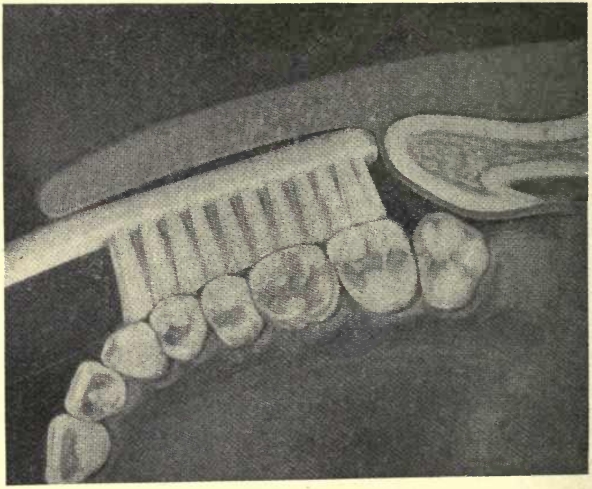
The occlusal surfaces of the teeth need little cleansing as a rule, but it is desirable to rub them with the brush by an in and out movement in the direction of the long axis of the handle. After cleansing the teeth the mouth should be thoroughly rinsed out with water forced between the teeth from the lingual to the labial and buccal sides. The brush should also be rinsed and hung up to dry.

7. Of equal importance with the use of the brush in the cleansing of the teeth is the use of the syringe. A syringe should be

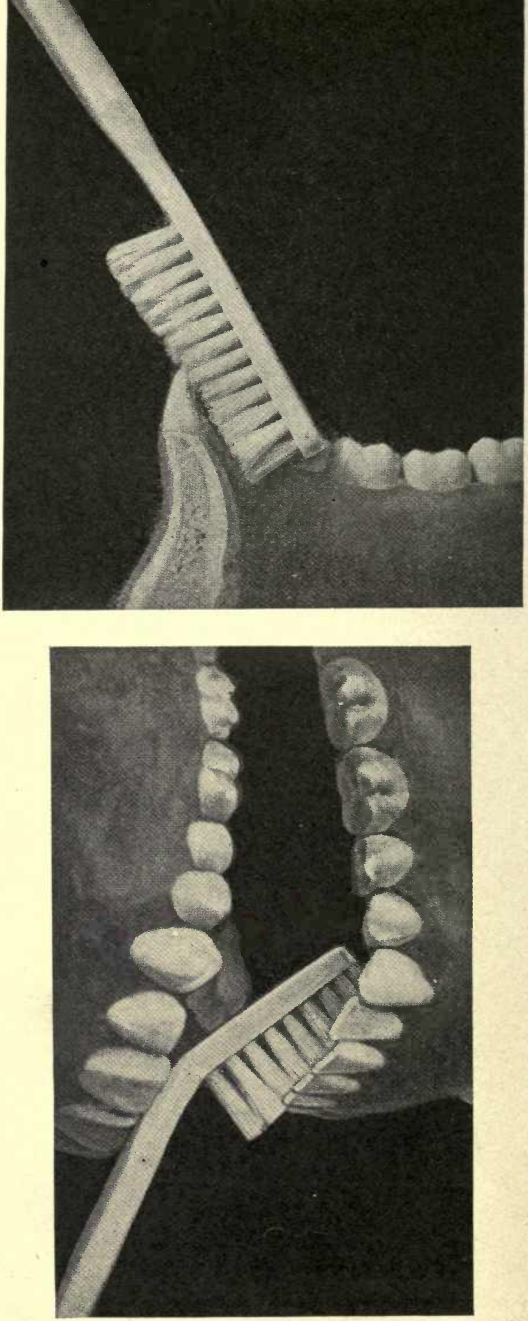


Figs. 51, 52, 53. Three tooth-brushes, actual sizes, for baby, youth and adult. All three have the bristles set sufficiently far apart and the brushes are generally good form. The brush in Fig. 51, ordinarily sold as a youth's size, is by far the best size for most adults, as there is better opportunity to manipulate it in the mouth. While some persons may use a brush as large as Fig. 53, it is too large to permit of proper movements in most mouths. (Black.)





Figs. 54 and 55. A "youth's" size brush to the buccal of the upper molars. In Fig. 55 the ramus in section is shown in its position in many mouths when the mouth is open, preventing the brush from reaching the third molar. In Fig. 54 the ramus is shown in its position when the mouth is closed, giving additional room for the brush. (Black.)



Figs. 56 and 57. In brushing to the lingual of the lower incisors the brush should be held parallel to the long axis of these teeth. Many people fail to brush the gums and gingival portions of the teeth in this position. If the brush has a handle bent as in Fig. 57 the end bristles will touch the gum.

fitted with a large rubber bulb capable of holding 1½ ounces of water. This should be fitted upon a nozzle 3 inches long, ending in a squirting extremity bending around in a short curve, and possessing an opening 1½ mm. in diameter.

With such a syringe it is possible to cleanse the subgingival spaces, both the proximal, besides the labial, buccal, and lingual. It is also possible to remove the food débris from the interproximal spaces and to empty any pockets which may have resulted from the detachment of the peridental membrane. With a little experience one may pass over the whole of both dentures with 8 syringefuls of water, a single syringeful being used for one surface of one denture from its distal extremity upon the third molar to the mid-line between the incisor teeth.

The water will find its way to the deepest part of the subgingival space. In fact, the majority of patients will soon come to feel the lifting of the gingivæ as the water enters the subgingival spaces. The syringe is so effective in its cleansing powers that patients once learning its use gladly continue with it.

Almost everyone will fail in some particular in the routine of cleansing the teeth properly. For this reason the advice of a dentist is quite essential at regular intervals. It is quite necessary that the dentist should supervise the effectiveness of his patients' attempts in cleaning their teeth and point out to his patients in what details the cleaning may be insufficient.

Artificial dentures and bridges, removable and fixed, should receive even more attention than the natural teeth. The denture collects beneath it the exfoliated epithelium of the mouth. This becomes mixed in places with food débris. Both of these forms of débris decompose and the products of decomposition become not only offensive, but irritating to the normal mucous surfaces. Moreover, bridges and other artificial appliances, even more than the natural teeth, form crevices beneath their edges in which food particles and other matter may accumulate.

The artificial denture may be placed under running hot water. After it has been washed in this manner, it should be brushed with a special brush. For this purpose a small hand brush with rather thickly set bristles is best. (See Fig. 58.) Special care should be bestowed upon that portion of the plate which covers the alveolar ridge. After the plate has been cleansed, any remaining teeth

and the mucous surfaces upon which the plate fitted must be cleansed. It is of the utmost importance that such surfaces should be washed free of deposit.

The proper care of bridges goes back farther than the cleansing process after they have been placed within the mouth. It concerns the manner in which they have been fitted to the mouth. They must be made and fitted in a manner that renders their cleaning an easy matter.

"No part of a bridge should press on the mucous membrane. It should be supported wholly by its abutments. Such an interval should exist between the edge of the bridge and the mucous membrane that a piece of tape can easily be inserted between the two and thus permit the rubbing of that part of the appliance which cannot be reached with the brush. For this to be effective the surface of the dummies towards the tissues should be convex from buccal to lingual rather than concave as many are made specially in the portion of the surface towards the lingual."

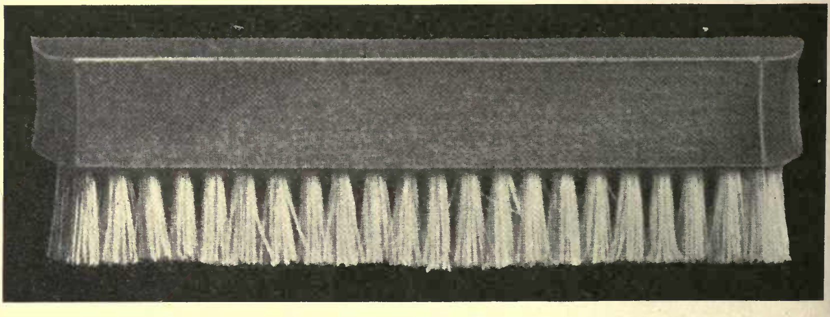


Fig. 58.. Special hand brush for cleansing the artificial denture.

Too great insistence cannot be laid upon the painstaking care which is not only necessary to use in the construction of bridges, but also upon the frequent examination of them, and alteration of them from time to time, in order that they and the surrounding mucous surfaces may be efficiently cleaned. They are by far the most difficult intra-oral artificial appliance to keep clean. Even when as originally placed, they may be satisfactory, yet later they may become a serious menace to health and even to life.

The toothpick is better avoided than resorted to as a means of cleaning the teeth, certainly in the mouth of the normal individual, and with few exceptions in all individuals whose mouths have been put in proper condition. It accomplishes nothing that cannot more safely be accomplished by the brush and syringe. It is possible that the use of the toothpick is justified in certain individuals in whose mouths the interproximal spaces have been widened by a recession of the gingivæ, whenever such individuals after eating cannot have access to the toothbrush or syringe or cannot effectively clean their mouths by a simple rinsing process.

The danger which comes from the use of the toothpick is the harm which may result from the trauma which they are so liable to inflict upon the gingivæ. The constant irritation of the gingivæ by the pressure or actual wounding of the gingivæ is no negligible factor in the excitation of disease in the peridental membrane. When toothpicks are resorted to, care should be taken to select a good quality of toothpick, one hard and smooth enough to be free from the splinters so often found in the cheaper grades. Quill toothpicks are either too broad or too yielding to be of service without the infliction of undue trauma.

Rubber bands and wax silk floss are more efficient and less harmful than toothpicks for cleaning the interproximal spaces. When they are used, they should slowly be carried past the contact point, using in this manner great care not to injure the gingivæ. The time and effort consumed in cleansing each interproximal space in this manner are so considerable that they constitute rather serious objections to this method. Moreover, even with care it is not always possible to avoid injuring the gingivæ. For these reasons, in the absence of special peculiarities of the interproximal spaces, it is desirable to dispense with the use of rubber bands and silk floss.

The above considerations comprise those procedures which are most desirable for keeping the normal teeth and gingivæ healthy. When deviations from the normal conditions occur, such as the beginning of decays or abnormal interproximal spaces, it is essential that these deviations should be corrected by the dentist in order that they may not be the cause of continued decay or progressive inflammation of the gingivæ.

Beginning decays have been classified by Black into the following:

1. **Pit and Fissure Decays in the Enamel**—The pit and fissure decays in the enamel may occur in the occlusal surfaces of the bicuspids and molars and in the buccal surfaces of the molars and lingual surfaces of lateral incisors. The majority of these decays occur early, soon after the teeth erupt. They are important because bacteria may grow in them and increase the size of the decay by their products. While the position of these decays makes it possible for them to be cleansed by special care, it is far more practical to make these defects "self-cleaning" by a proper filling.

2. **Proximal Decays**—Proximal decays occur on the smooth surface of the enamel just to the gingival side of the point of contact. The majority of these decays occur between the 10th and 25th year. They can occur only after there has been a slight recession of the septal gingivæ. These decays may be prevented from extending, if only beginning by polishing the area to the level of the surrounding surface and thereafter conscientiously cleaning the interproximal spaces with tape or silk floss. An inch or two of the latter may be moistened and then dipped into pumice and used daily by the patient to clean an interproximal space so affected.

3. **Decays upon the Gingival Third of the Buccal, Labial and Occasionally upon the Lingual Surfaces**—The decays upon the gingival third of the buccal, labial and upon the lingual surface are less frequent and met with later in life, most of them after the 20th year. They can all be prevented by brushing the teeth. When of slight depth they may be ground down to the level of the surrounding surface and afterwards the surface kept clean by more careful daily cleansing of the teeth.

Of equal importance with the prophylaxis against dental caries is the prophylaxis against disease of the peridental membrane. Slowly and surely, unless protected from the various agencies which wear this only support of the teeth away, it gradually recedes from the roots of the teeth, not only leaving their roots exposed until the teeth actually fall out, but in the process forming between it and the teeth, will form chronic suppurating pockets which possess full potential powers for undermining the constitution of the victim.

The causes of inflammation of the peridental membrane are as follows:

1. The Collection of Salivary Calculus upon the Teeth—According to the researches of Black, salivary calculus is a deposit of calcoglobulin which when present in excess in the saliva becomes deposited upon the teeth at first in the form of a greasy, sticky, soft coating. It is insoluble in water and coagulable by heat from its solutions in neutral salts. When first deposited, it is easily removed by a stream of water as from the oral syringe. It soon, however, undergoes a hardening and becomes more and more difficult to remove. It can be readily removed within five to twelve hours after it is deposited, but after 24 hours the hardening has progressed so far that it is difficult to remove with a brush. After a week it can no longer be brushed away, and after one or two months instruments must be used to break it away.

To a certain extent the presence of this calcoglobulin in the saliva in a sufficient concentration to precipitate, depends upon the individual. The teeth of some individuals never collect calcoglobulin; in other individuals the greatest care is needed to prevent the formation of thick deposits, but the relation between generous diet and the tendency to the deposit of salivary calculus is so marked that even individuals most susceptible in this particular can wholly prevent the formation of calcoglobulin by eliminating from their diet that excess over and above an amount which is sufficient to satisfy their energy requirements. In other words, indulgence in an excessive diet causes excessive quantities of calcoglobulin in the saliva.

Salivary calculus is always deposited upon the teeth (never upon the mucous membranes), at the free margin of the gingivæ. If allowed to remain it thickens and by pressure it destroys the gingivæ, which become thickened and shortened. (See Figs. 59, 60, 61, and 62 for illustration of the progressive shortening of the gingivæ, even to the destruction of the alveolar borders. See Figs. 63, 64, 65 and 66 for further illustration of the destruction of tissues due to salivary calculus.) The prophylaxis of the condition depends upon an avoidance of an excessive diet and of the faithful use of the toothbrush and oral syringe.

2. Serumal Calculus—The term serumal calculus is applied to a deposit of calcoglobulin upon the enamel of the subgingival

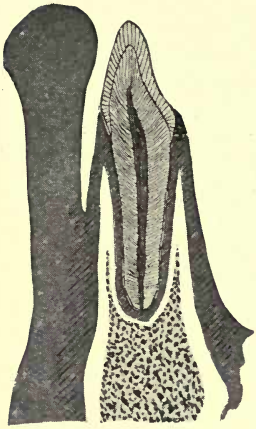


Fig. 59. Drawings to illustrate the progressive destruction of the investing tissues caused by deposits of salivary calculus.

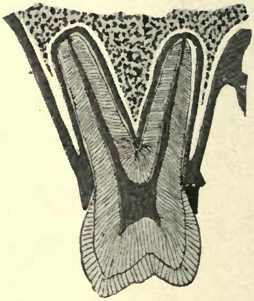


Fig. 60 shows a similar deposit on the buccal surface of an upper molar.

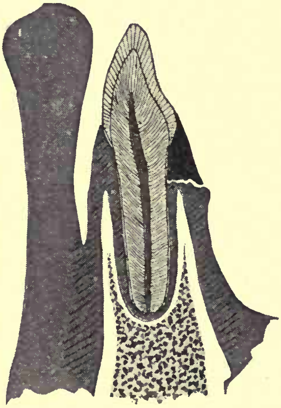


Fig. 61 shows a slight deposit on the lingual surface of a lower incisor which has caused a gingivitis only, not having progressed far enough to involve the attachment of the peridental membrane to the cementum.

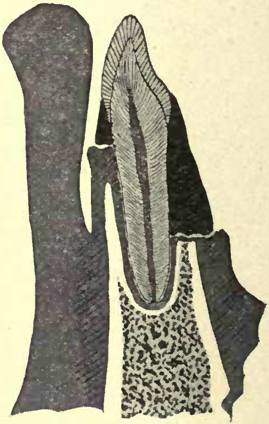


Fig. 62 shows a more extensive accumulation on the lingual of a lower incisor than shown in Fig. 61. It will be noticed that the gingival line of the tooth has been passed and the deposit has almost reached the crest of the bone.

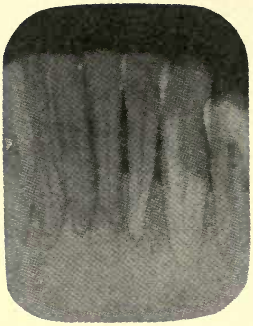


Fig. 63. Illustrations showing the destruction of the investing tissues by deposits of salivary calculus.

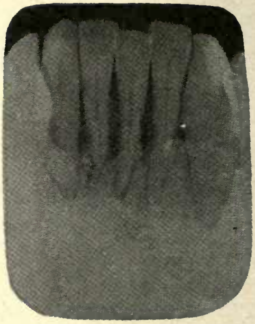


Fig. 64 is a reproduction of radiograph showing extensive destruction of the alveolar process.

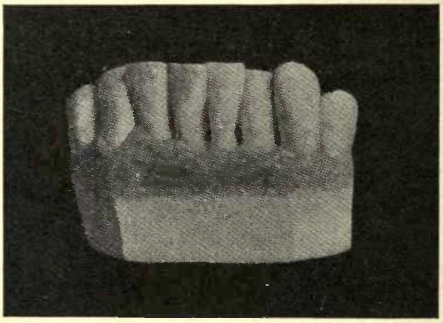


Fig. 65 is from a plaster cast of a case in which the deposit was nearly as extensive on the labial as on the lingual of the lower incisors. In this case the septal tissues were destroyed by the use of a wooden toothpick, rather than by the deposits.

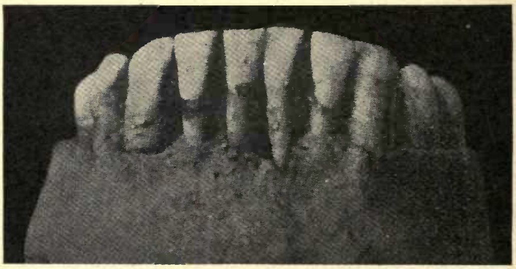


Fig. 66 is from a skull. This shows the destruction of the bone, which is especially deep between the central incisors. Spec. from Northwestern University Dental Museum. (Black.)

space. The deposit in this instance does not come from the saliva, but from the excess of calcoglobulin contained in the serum bathing these spaces. This different origin is made evident by the contrast in the location of salivary calculus and the favorite sites of collection of serumal calculus. The former occurs more frequently upon the back teeth or those in relation to the salivary ducts, while the serumal calculus is more apt to occur in the front part of the mouth, especially upon the incisors and bicuspids.

While it should generally be expected that salivary calculus should be present in mouths in which serumal calculus is present, such is not necessarily the case. This circumstance is probably due to the fact that local conditions of the nature of a beginning irritation of the gingivæ, or differences in which certain portions of the denture are subject to natural processes of cleansing during mastication, have something to do with the deposit of one or the other form of calculus. Serumal calculus is more compact and harder than salivary calculus. Its color is dark brown, often intensely black, and when broken, washed and dried it becomes lustrous. (See Figs. 67, 68 and 69 for deposits of serumal calculus and the manner in which they may provoke a gingivitis.)

The prophylaxis of serumal calculus is the same as the prophylaxis of the salivary calculus: namely, the faithful use of the toothbrush and the syringe. The possibility of the formation of these deposits should necessitate regular visits to the dentist, who should, in those individuals who cannot be educated to keep their mouths free of the deposits, remove them at frequent intervals and at the same time instruct the patient in better methods of cleaning the teeth.

3. Faulty Contact Points—Unquestionably the most frequent cause of gingivitis is faulty contact points, particularly in the molar and bicuspid region, where the heavy work of mastication is done. An open space between two adjacent contact points means that particles of food, especially food of a stringy nature, will be crowded down upon the septal gingivæ with each occlusion in the act of chewing. As a result of repeated pressure and irritation, the tissue becomes inflamed and finally suppuration supervenes in the line of attachment of the peridental membrane to the cementum, extending in a direction from the occlusal surface

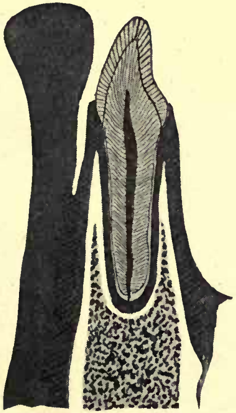


Fig. 67. Drawings to illustrate the positions in which deposits of serumal calculus occur on the surface of the enamel in the subgingival space. Deposits in this position are usually flat scales, while those on the roots are more generally nodular. Fig. 67 shows small deposit on labial surface of a lower incisor.

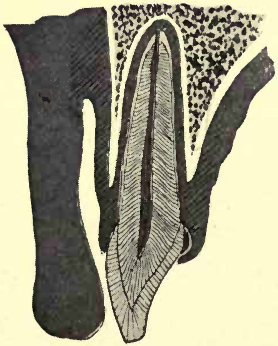


Fig. 68 shows a deposit of serumal calculus under the free gingiva on the lingual surface of the enamel of a lower incisor tooth.

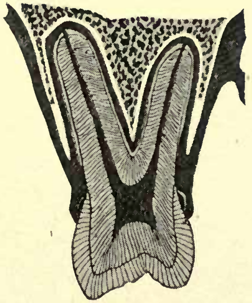


Fig. 69 shows a similar deposit on the lingual surface of an upper incisor. Suppuration of the peridental membrane, resulting from deposits in this position, causes the teeth to move labially, and such cases are generally hopeless after much progress has been made.

of the teeth toward the apex. The inflammation may or may not be accompanied with the deposit of serumal calculus.

Lack of contacts between the teeth may be due to separations between teeth caused by the extraction of a tooth: if, for instance, a first molar is extracted, the second molar and second bicuspid will be drawn together, causing slight opening of the contacts on the opposite sides of these teeth. Uneven occlusal wear or occlusions originally abnormal upon the cusps may cause a separation or weakening of contacts. Weak contacts may be due to a weakening of the pull of the septal fibers of the peridental membrane. In such cases the pressure of certain kinds of food may be sufficient to force the contact points apart.

Decays beginning in the proximal surfaces of the teeth may progress until the occlusal surface of the enamel is undermined and finally the undermined margin lost. Through such a defect the food during the mastication will be forced down upon the septal tissue. Fillings and crowns may be so improperly finished that they fail to restore the proper contact with adjacent teeth. Too broad a contact between teeth may be responsible for entrapping stringy food between the teeth and for resulting in undue pressure upon the septal gingivæ. Sometimes such broad contacts may depend upon an abnormal position of a tooth which causes it to slant and thus come into contact with its neighbor by a wide surface.

Interproximal wear resulting from slight buccolingual motion of a tooth during mastication may lead to a widened and loose contact. In this manner facets of considerable size may be worn between adjacent teeth between the contact point. Gingivitis may be caused by the direct injury inflicted upon the gingivæ by the sharp irregular edges of proximal carious cavities, or by imperfectly finished filling, or by crowns or bridges which may have been improperly finished or which either impinge upon the gingivæ or allow abnormally large gaps between the gingivæ and teeth and which are so shaped that the particles of food may pack into the crevice. Finally, gingivitis may be due to direct injury of the gingivæ by either the dentist or the victim himself. One of the worst forms of injury may be due to the drawing of the ligature roughly down between the teeth upon the septal gingivæ or even the careless leaving of ligatures in place.

The gingivæ are not infrequently injured by carelessness in the use of instruments in the various operative procedures upon the teeth. The greatest care should be exercised in the restoration of the normal contact between teeth and in the protection of the gingivæ against the lodgment of food in abnormal crevices and pockets about the teeth; and finally against direct injury from improperly finished artificial work or the still more direct instrumental injury.

Two other subjects must be considered a part of the general discussion on the hygiene of the mouth. Both more properly belong to the field of oral surgery but their prophylaxis is so essentially of hygienic importance that their consideration here cannot be omitted.

They are the relation of chronic irritation within the mouth to the development of cancer in this cavity and the relation of hypertrophied tonsils and adenoids to ill health.

The Relation of Chronic Inflammation in the Mouth to the Development of Cancer—However much debated the cause of cancer may be, yet it is an established clinical fact that no exciting cause so frequently leads to the development of cancer inside the mouth as prolonged trauma to its mucous membrane. Such prolonged trauma may be caused by a sharp, ragged edge of a tooth or a rough, unprotected edge of a bridge or poorly fitting plate, a large solitary calculus or the presence within the mouth of chronic inflammation surrounding a carious tooth or the opening of a sinus leading down to an area of necrosed bone. All these conditions frequently lead to chronic ulceration which only too frequently leads to the development of true cancer. Another form of irritation not to be overlooked is the chronic irritation of tobacco smoke, particularly if there is added the additional irritation of a rough end of a pipe or the intensification of the effect of tobacco smoke upon some one place in the mouth as would result from the constant holding of the cigar or pipe in the same place in the mouth.

Finally it must not be forgotten that the association of tertiary syphilis and cancer is not uncommon. The superficial leucoplakias and the chronic diffuse productive inflammations occuring so often on the tongue in tertiary syphilis are not infrequent precursors of cancer.

The Relation of Adenoids and Hypertrophied Tonsils to Ill

Health—Excessive hypertrophy of the tonsils and adenoid tissue of the nasopharynx leads to ill health of quite a different character. These conditions usually occur in childhood but the evil train of consequences following them frequently persist through life. When this tissue becomes hypertrophied, it so fills the space of the nasopharynx that it interferes seriously with nasal breathing and renders deglutition more or less difficult. The nasopharynx is not infrequently completely blocked and during each inspiration and also during deglutition there occurs a rarefaction of the air in the nasopharynx which leads to increased congestion and secretion in the nasopharynx. The mouth is constantly held open and the pressures, including both the muscular pressure and atmospheric pressure upon the hard palate, are not counterbalanced as under normal conditions by the passage of air through the nose and the action of the lingual muscles, producing suction and a laterally spreading effect upon the hard palate. All of these factors are concerned during nasal respiration.

As a result of this altered muscular activity and changed air pressures within the mouth and nasal cavity the nasal space fails to develop to its normal size and capacity. It becomes contracted not only at its anterior and posterior openings and from the sides but also, and to a prominent degree, from below. The arch of the hard palate is very high. This alteration of the arch of the hard palate affects in turn the development of the teeth. The anterior teeth of the upper jaw become cramped together and tend to project forwards. The transverse diameter of the mouth is contracted. There is a tendency for the molars to depart from the vertical plane and be directed inwards. The deformity of the upper jaw seriously affects the development of the lower jaw as the teeth acquire those positions into which they are forced by articulation with their antagonists. Patients who have suffered with adenoids present a typical appearance. The nose is small, the anterior upper incisors project in front of the lower incisors. The mouth appears contracted in its transverse diameter and the arch of the hard palate is abnormally high.

The lower jaw is undeveloped and receding. The patients habitually breathe through the mouth and during the period of greatest hypertrophy which occurs during childhood and adolescence there is a constant discharge of mucus from the nose. The poor victims

appear to be suffering from a chronic cold with many acute exacerbations.

The effect on the general health and the development of both mind and body is most serious.

The afflicted individuals are constantly swallowing and aspirating the bacteria containing discharges from the nasopharynx.

The surface of the enlarged tonsils are covered with crypts and within these and the crevices between the adenoid papillæ the bacteria collect and develop and may enter the system either directly or by passing into the lymph and blood stream or they may be inhaled.

Tuberculosis in its various forms is a frequent complication of adenoids and enlarged tonsils. The most serious effect upon the victim, however, comes from the embarrassment of respiration and of the free access of oxygen to the lungs. It is as though the individual was constantly living in a confined atmosphere.

All these individuals are poorly developed as to their bodily size and muscular strength and this depression of the developmental activity includes the brain. All these victims show more or less blunting of their intelligence.

The contrast which these patients present before and after the operative removal of their tonsils and adenoids well emphasizes the serious stunting of their bodily and mental vitality.

Before operation many of these children appear half idiotic with their mouth constantly open and their bodies undersized and brains incapable of any serious mental effort.

They are behind their companions in all these particulars. Their backwardness at school is especially noticeable. After operation they actually begin to grow. Not only do their faces change but they rapidly overtake their companions physically and mentally.